Storm Water Management Model Workshop

Conference Proceedings No. 4

Research Program for the Abatement of Municipal Pollution
under Provisions of the Canada-Ontario Agreement
on Great Lakes Water Quality

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STORM WATER MANAGEMENT MODEL WORKSHOP

held in

Toronto, Ontario

October 19, 20 and 21, 1976

CANADA-ONTARIO AGREEMENT ON
GREAT LAKES WATER QUALITY

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PREFACE

The Second Canadian Storm Water Management Model Workshop dealt with Urban Storm Water Management Modelling and, in particular, with the Storm Water Management Model. Under provisions of the Canada-Ontario Agreement on Great Lakes Water Quality, the firms of Proctor & Redfern Limited, James F. MacLaren Limited, and Dorsch Consult Limited were commissioned to modify and further develop the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM)*. These modifications were particularly related to Canadian conditions. For example, one of the largest additions to the model was a new snowmelt routine which is also being implemented in the official U.S. version. Additional work has been conducted on other blocks of the model; for example, a study of simplified simulation using the SWMM was carried out. New routines for managing and analyzing the large quantities of meteorological data have been written and are included in the presentations.

The SWMM version which resulted from this joint study was the subject of this workshop. The goals were, firstly, to provide some background to the technology of urban storm water modelling. This is a rapidly changing field, and to properly use the model, an appreciation of the overall state-of-the-art is necessary. Secondly, it was intended to provide those attending the workshop with enough information to begin modelling on their own. Instruction was given on the setup and conduct of a simulation for a specific problem area using the Canadian SWMM. The workshop was also intended to initiate interest in the use of SWMM in Canada, even among those who will not be directly involved in running the model. There are numerous potential applications of the SWMM and related models in Ontario today. Large numbers of combined and separate sewer systems are in existence which discharge overflows to receiving water bodies. As the systems become larger and more complex, the use of computer models to standardize and facilitate the analysis and computation of flows in these systems is more and more necessary. Computer models, such as the SWMM, represent an attempt not to replace, but to support engineering judgement.

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* Refer to Canada-Ontario Agreement Research Reports No. 47, 48 and 62.

Finally, the latest refinements of the SWMM model which were carried out recently by the University of Florida under the sponsorship of U.S. EPA are presented.

The sessions consisted of both lectures and practical workshop experience. In the lectures, background material and theory behind the models and their computations, as well as instructions in their use, are presented. In the workshops, some practical problems were posed, input data was prepared and simulation results were distributed and discussed.

AVANT-PROPOS

Le deuxième atelier sur les modèles de gestion des eaux pluviales a porté notamment sur le STORM WATER MANAGEMENT MODEL (SWMM) de l'EPA des Etats-Unis. Aux termes de l'accord entre le Canada et l'Ontario sur la qualité de l'eau des Grands lacs, les services des firmes Proctor & Redfern Limited, James F. Maclaren Limited et Dorsch Consult Limited ont été retenus* pour modifier et améliorer le SWMM, en vue surtout de l'adapter aux conditions climatiques canadiennes. C'est ainsi qu'un des ajouts les plus importants, un sous-programme de la fonte des neiges, est actuellement exploité ici comme au E.-U. D'autres aspects ont également été touchés: l'étude d'une simulation simplifiée, menée à l'aide du SWMM, en offre un exemple. De nouveaux sous-programmes sur le traitement et l'analyse d'une grande quantité de données météorologiques ont été rédigés et communiqués lors des séances.

L'objectif de l'atelier était de présenter, à la suite de ces réflexions en commun, un modèle modifié du SWMM ainsi que les techniques de base permettant d'établir des modèles s'appliquant aux eaux pluviales urbaines.

A cause de l'évolution rapide de ce domaine, il était nécessaire d'en bien faire connaître les plus récents progrès afin de s'assurer d'une application adéquate du modèle. Il a également fallu fournir aux participants suffisamment d'informations pour leur permettre de construire leur propre modèle. Des instructions ont été données pour simuler, au moyen du SWMM (version canadienne), un problème donné. L'atelier visait aussi à promouvoir l'utilisation du SWMM au Canada, même auprès de ceux qui n'étaient pas directement concernés par son application. Il existe présentement en Ontario, de nombreuses possibilités d'usage du SWMM et des modèles connexes. Actuellement, beaucoup de systèmes d'égouts, séparés ou unifiés, déversent leur trop-plein dans les eaux réceptrices. A mesure qu'ils augmentent en importance et en complexité, il devient de plus en plus impérieux de recourir aux méthodes informatiques pour uniformiser et faciliter l'analyse et le calcul des débits. Les modèles comme le SWMM ne sont pas conçus pour remplacer les ingénieurs, mais pour faciliter leur travail.

Les dernières améliorations que l'Université de la Floride a apportées au SWMM, pour le compte de l'EPA, ont aussi été signalées.

Les séances comprenaient des ateliers pratiques et des conférences axés sur le matériel de base, la théorie et les calculs des modèles, ainsi que les consignes d'utilisation. Les ateliers ont fourni l'occasion de poser des problèmes pratiques, d'en préparer les paramètres d'entrée, de communiquer et de commenter le résultat des simulations.

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* Voir les Canada-Ontario Agreement Research Reports n^{os} 47, 48 et 62.

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OBJECTIVES OF STORM WATER MODELLING - OUTLINE

Preliminary Lecture Outline for
Wayne C. Huber
Department of Environmental Engineering Sciences
University of Florida

I. Objectives of Storm Water Modelling
    A. Overall - To aid in decision making
    B. Subobjectives - Planning, Design, Operation

II. Overview of SWMM
    A. Development and history
    B. Model structure
    C. Data and computer requirements

III. Overview of the Runoff Block
    A. Quantity routing
    B. Discretization
    C. Quality routing and pollutant loadings

IV. Recent Modifications to the Storage/Treatment Block

V. Overview of the Receiving Block
    A. Schematization
    B. Quantity techniques
    C. Quality techniques

OBJECTIVES OF MODELLING IN URBAN DRAINAGE STUDIES

Paul E. Wisner
James F. MacLaren Limited

INTRODUCTION

The urban drainage system is part of the total urban water resources system (Figure 1). Traditional design and planning in urban water resources considered the following elements of the total system more or less independently:

(a) the water supply system,
(b) the urban drainage system,
(c) the wastewater system.

Flood control for major streams in the metropolitan area was also analyzed independently in watershed studies.

Although the interrelations between these subsystems are now widely accepted and the need to consider them in integrated planning is recognized, there has been limited experience with this approach. Problems discussed at this workshop represent only one facet of a systems approach to urban planning.

The object of past drainage studies was generally straightforward: sizing of pipes, culverts or channels for rapid removal of runoff caused by a storm with a given frequency. The success of the Rational formula and its persistence in engineering practice, despite its known shortcomings, may be explained partly because it provided a quick estimate of peak flow and it was relatively well understood by all those involved in the studies. Design of sewer systems based on this approach leads to a quick removal of storm water and increases in downstream peak flow rates. Large investments in drainage facilities may be required to prevent flooding resulting from the increased flows.

As a result of climbing costs of drainage works and an increasing awareness of the environmental impacts of runoff, it is apparent that a broader approach to drainage studies is required. For example, control of runoff from new urban developments is receiving increasing acceptance as an environmental management objective. Peak runoff rates after develop-

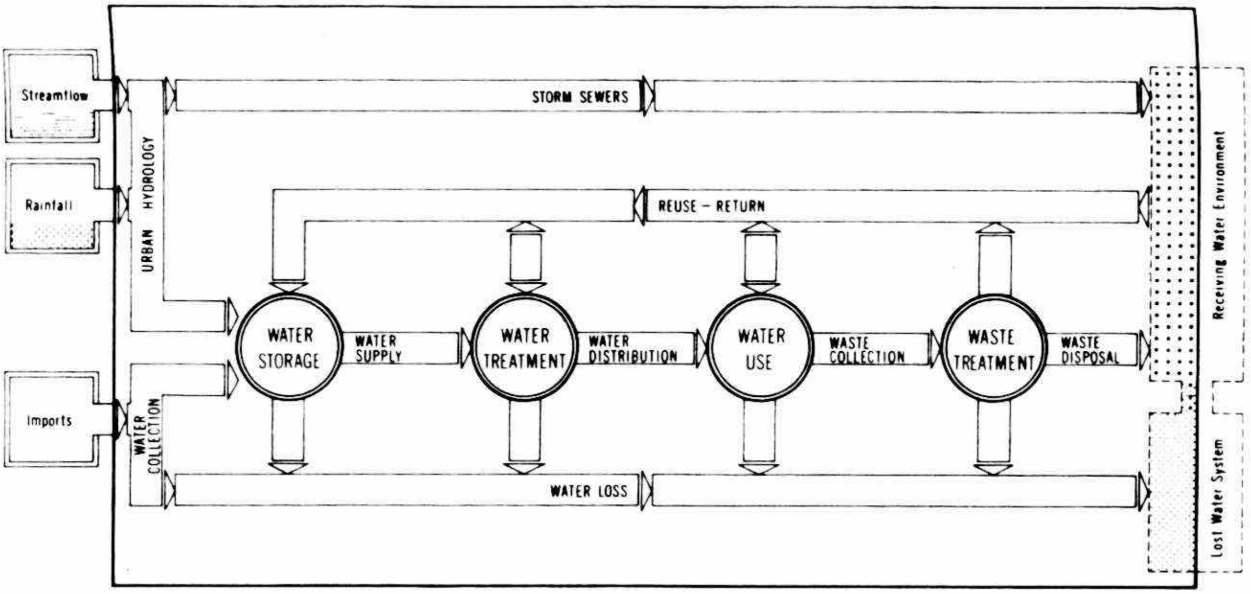


FIGURE 1. THE URBAN WATER RESOURCES SYSTEM

ment may be required not to exceed runoff rates under predevelopment conditions. The Rational formula is not a suitable method for evaluation of the storm water management techniques, such as storage, required to control runoff rates.

The problem of control of pollution of receiving waters from point and non-point sources is being examined closely. Combined sewer systems have been designed with interception and treatment capacities of from 2 to 5 times the dry weather flow rates. In order to reduce the frequency of untreated overflows, separation of combined sewers has begun in some cities. This solution results from consideration of the urban runoff system and the sanitary waste collection system as non-interrelated subsystems of the urban system.

Many measurements have indicated that urban runoff is relatively polluted (Figure 2) and detrimental effects, both immediate and long-term, may result from storm water discharges to receiving water bodies. Hence, combined sewer separation may not be the optimum solution from an environmental viewpoint. Since the cost of separation is prohibitive for many older cities, alternative measures for alleviation of receiving water pollution should be investigated.

Advanced storm water management techniques and associated computer-based models for accurate flow prediction have been developed

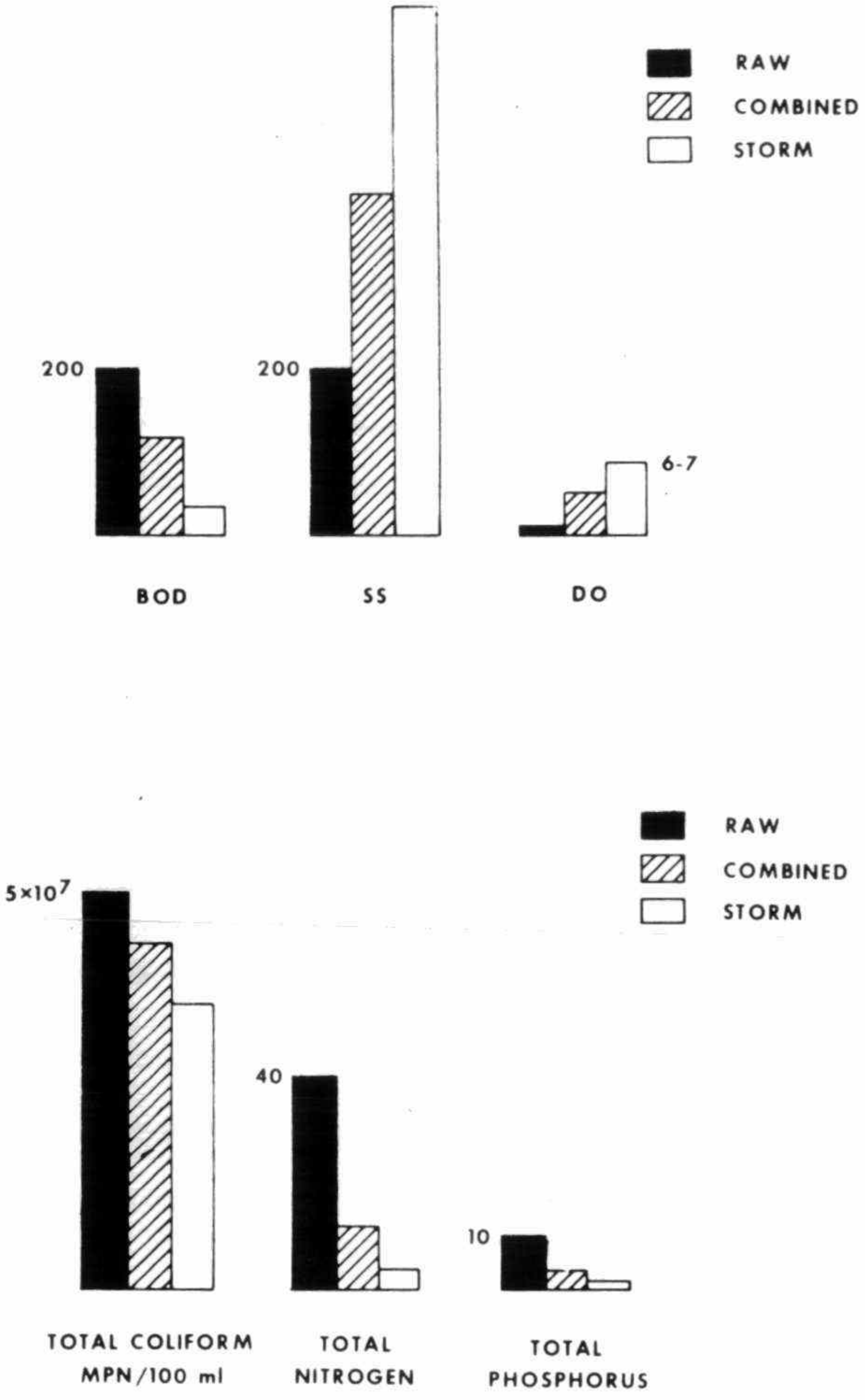


FIGURE 2. REPRESENTATIVE STRENGTHS OF WASTEWATERS (flow weighted means expressed in mg/l)

and implemented as a result of pressures for a better solution to these and similar problems. Models offer the means for comprehensive sewerage studies integrating aspects of collection and transport of urban runoff, and the effects of combined sewer overflows and discharges of treated effluents. With a modelling approach, a range of alternatives for total system management can be investigated on a cost-effectiveness basis.

GENERAL MODELLING

This workshop will discuss in detail different aspects of urban runoff simulation, and our intention is to describe the principles of different computer models and cover several applications. Although this lecture covers only general principles of modelling and general aspects related to modelling objectives, we should be aware that:

- modelling is an art rather than a science,
- the state of this art is rapidly changing,
- there is limited experience with model applications,
- there is a plurality of modelling approaches,

and, therefore:

- principles are more important than formulae.

Implementation of storm water management models represents not only a change in computational sophistication, but also a change in design philosophy. In the traditional approach, "drainage projects" were considered as more or less straightforward design applications. A single person was often responsible for all aspects of a project including hydrologic computations using the Rational formula, sanitary engineering, selection of project alternatives and detailed design.

If models are applied within the framework of "storm water management projects", a study is conducted not by a single person, but by a team whose members have expertise in the different aspects of the project. It is important that the team members be aware not only of the advantages of modelling but also the pitfalls of modelling in general, and urban drainage modelling in particular.

Modelling is always only one of the elements (and often not the most important element) of an analysis designed to assist the decision-maker in the selection of an "optimum" design or policy alternative.

The decision must be reached by an individual or an agency under given time and budgetary constraints, based on limited information, and within an existing institutional and political environment. Development of a modelling approach must be compatible with all these factors and with the general plan of the analysis.

The modeller is, in general, a member of a study team and he should have a good appreciation of the overall scope of the study. He should also familiarize the other team members with the basic principles and with the limitations of the modelling.

Substitution of traditional methods with the more sophisticated ones presented at this workshop has a disadvantage in the potential for increased difficulties in communication between those involved in a study. These difficulties may include resolution of study objectives, selection of suitable models and application of the models.

It should also be remembered that the choice of criteria for comparison of alternatives rests with the decision-maker. While the modeller may desire to use the tool which gives the "best prediction", the decision-maker may be more concerned in his selection with intangible aspects of the project which cannot be modelled mathematically.

RUNOFF CONTROL IN NEW DEVELOPMENTS

Urbanization of a rural watershed results in significant physical changes. The main changes which affect runoff are:

(a) Increased Imperviousness - Runoff from an area is directly related to its imperviousness, i.e. the fraction of the area covered by impervious surfaces. Imperviousness is a function of population density, and typical imperviousness data are given in Table 1.

(b) Increased Density of Drainage System - A characteristic measure of the density of a drainage system is the ratio $L/A^{0.6}$,

where L = the total length of drainage conduits (km)
and A = the total drainage area (km^2).

TABLE 1. IMPERVIOUSNESS RANGES FOR TYPICAL URBAN DEVELOPMENT

Land Use	Percent Imperviousness
Low Density Residential	20-30
Medium Density Residential	25-35
High Density Residential	30-40
Business-Commercial	40-90
Light Industrial	45-65
Heavy Industrial	50-70

Another estimate of imperviousness for typical urban development has also been offered:

Land Use	Percent Imperviousness		
	Low	Intermediate	High
Single-Family Residential	12	25	40
Multiple-Family Residential	60	70	80
Commercial	80	90	100
Industrial	40	70	90
Public and Quasi-Public	50	60	75

Analysis of urban drainage systems has indicated that this ratio varies from 20 in Los Angeles to 120 in New York (Table 2). A typical value for the same ratio in rural systems is 2.

(c) Lower frictional resistance - Sewers or improved channels have a lower roughness coefficient than natural watercourses and flow velocities in them are much higher.

Urbanization affects the hydrologic cycle and results in changes in climate, runoff quantity and quality and groundwater characteristics. For example, thunderstorm frequency in Chicago is 31 percent higher than in the adjacent rural areas. Changes in surface cover lead to a reduction in interception. Evaporation losses from ponds are increased by urbanization and losses from channels and overland flow are decreased. Groundwater tables are lowered by over-exploitation and by reduction in infiltration.

TABLE 2. DENSITY OF UNDERGROUND DRAINAGE CONDUITS IN SOME MAJOR CITIES

City	Area of City, A, $Km.^2$	Total Length of Storm and/or Combined Sewers, L, Km.	L/A, $Km./Km.^2$	$L/A^{0.6}$, $Km./(Km.^2)^{0.6}$
Boston, Mass.[a]	124	2,190	17.6	121
Chicago, Ill.[a]	580	5,786	10.0	127
Detroit, Mich.[a]	360	4,656	13.0	136
Los Angeles, Cal.[b]	1,191	1,389	1.2	20
Milwaukee, Wis.[c]	246	2,205	9.0	81
New York, N.Y.[d]	829	6,650	8.0	118
Philadelphia, Pa.[e]	337	4,023	12.0	122
Saint Louis, Mo.[a]	160	1,796	11.2	85
San Francisco, Cal.[a]	114	1,400	12.3	82
Washington, D.C.[a]	158	2,816	17.8	135

a: Hallmark, Dasel E., and John G. Hendrickson, Jr., "Study of Approximate Lengths and Sizes of Combined Sewers in Major Metropolitan Centers," ASCE Combined Sewer Separation Project, Technical Memorandum No. 4, ASCE, N.Y., N.Y., May 1, 1967. (NTIS Id. No. PB 185 999).

b: Bauer, W. J., "Economics of Urban Drainage Design," Journal Hydraulics Division, ASCE Proc., Vol. 88, No. HY6, Paper 3321, November, 1962.

c: Prawdzik, T. B., "Environmental and Technical Factors for Open Drainage Channels in Milwaukee," ASCE Urban Water Resources Research Program, Technical Memorandum No. 12, ASCE, N.Y., N.Y., February, 1970. (NTIS Id. No. PB 191 710).

d: (Unpublished notes of ASCE Combined Sewer Separation Project, November 15, 1967).

e: Radziul, J. V., C. F. Guarino and W. L. Greene, "Combined Sewer Considerations by Philadelphia," Journal Sanitary Engineering Division, ASCE Proc., Vol. 96, No. SA1, Paper 7050, February, 1970.

The hydrologic changes which are simulated by the models presented at this workshop include the following important characteristics of storm runoff:

A. Increase in Peak Runoff

This increase is caused by the combination of factors (a) and (b) discussed above. The mechanism of runoff increase from a watershed is explained in Figure 3 which compares infiltration losses and reduction in lag time or equivalent reductions in time of concentration. Results from measurements on the same watershed during its urbanization are presented in Figure 4.

B. Increase in Pollution Loading

Pollutants accumulate on urban surfaces as a result of normal urban activities. The loadings of contaminants in storm water runoff from the urbanized area are generally substantially higher than the corresponding loadings from the pre-developed area (See Figure 5). Examples of measurements of storm water constituents will be given in other lectures.

There are many alternatives which can be considered in order to reduce peak runoff increases caused by urbanization. Some examples are:

(a) Rooftop and/or Parking Lot Storage
(b) Porous Pavements
(c) Infiltration Ditches and Recharge Ponds
(d) Detention Ponds
(e) Ditch and Swale Systems - No Storm Sewers
(f) No Channel Improvements
(g) Storm Sewer Surcharge

Figure 6 shows the effect of one inch of parking lot storage on the runoff hydrograph from a shopping centre. An example of the peak flow reduction with a pond servicing a small development is given in Figures 7 and 8. Quality improvements may also be obtained by detention.

All the above alternatives may lead to savings in drainage works because of peak flow reduction. Downstream effects caused by release from storage have to be considered in order to avoid superposition of the outflow with peak flows from other areas.

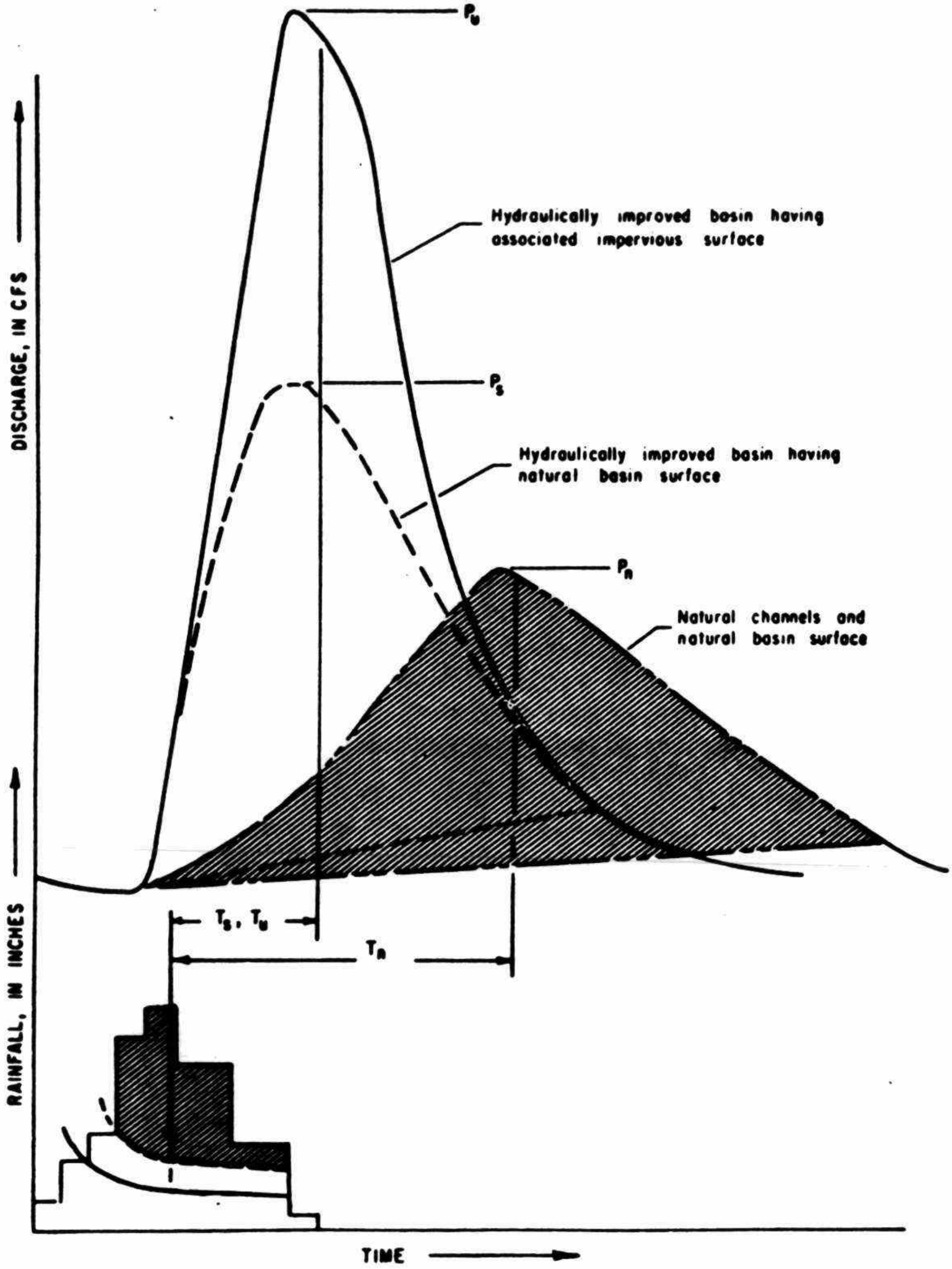


FIGURE 3. SCHEMATIC DRAWING ILLUSTRATING THE EFFECTS OF URBAN DEVELOPMENT ON FLOOD HYDROGRAPHS. Hydrographs are not to Scale. T_n, T_s, and T_u, Lag Times; P_n, P_s, and P_u Flood Peaks of the Hydrographs for the Three Basin Types Shown.

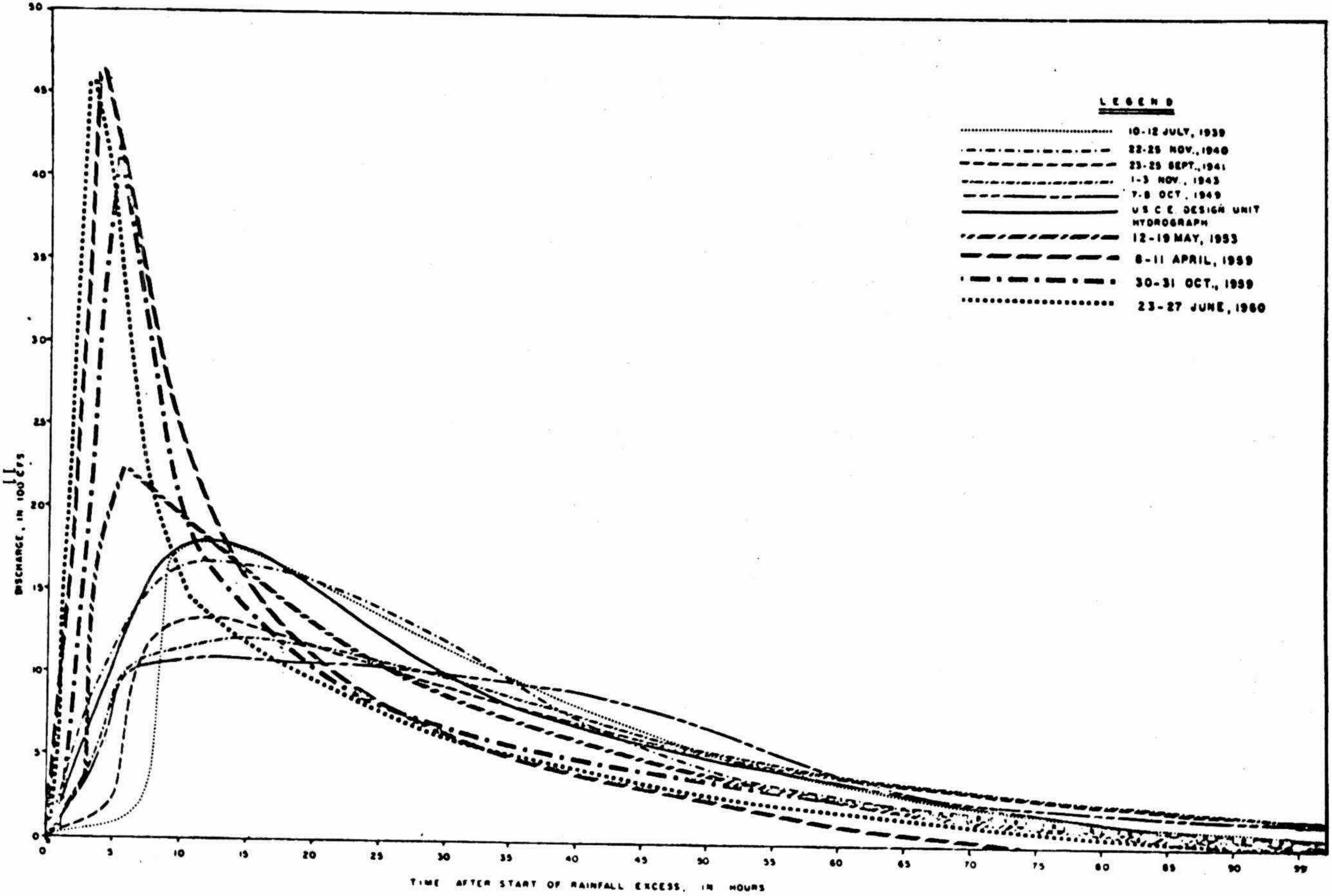


FIGURE 4. BRAYS BAYOU UNIT HYDROGRAPHS, 1939-1960, SHOWING EFFECTS OF WATERSHED DEVELOPMENT

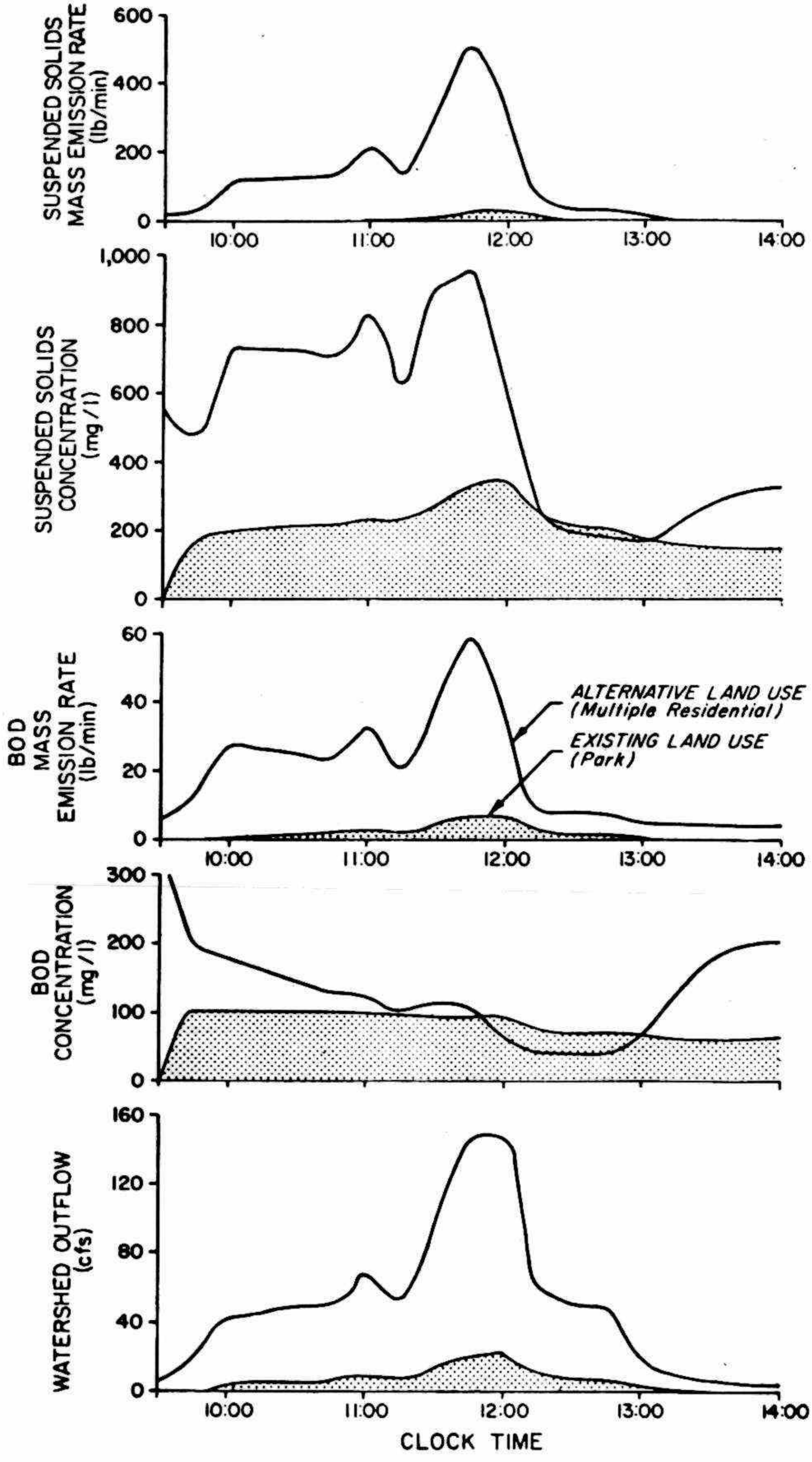
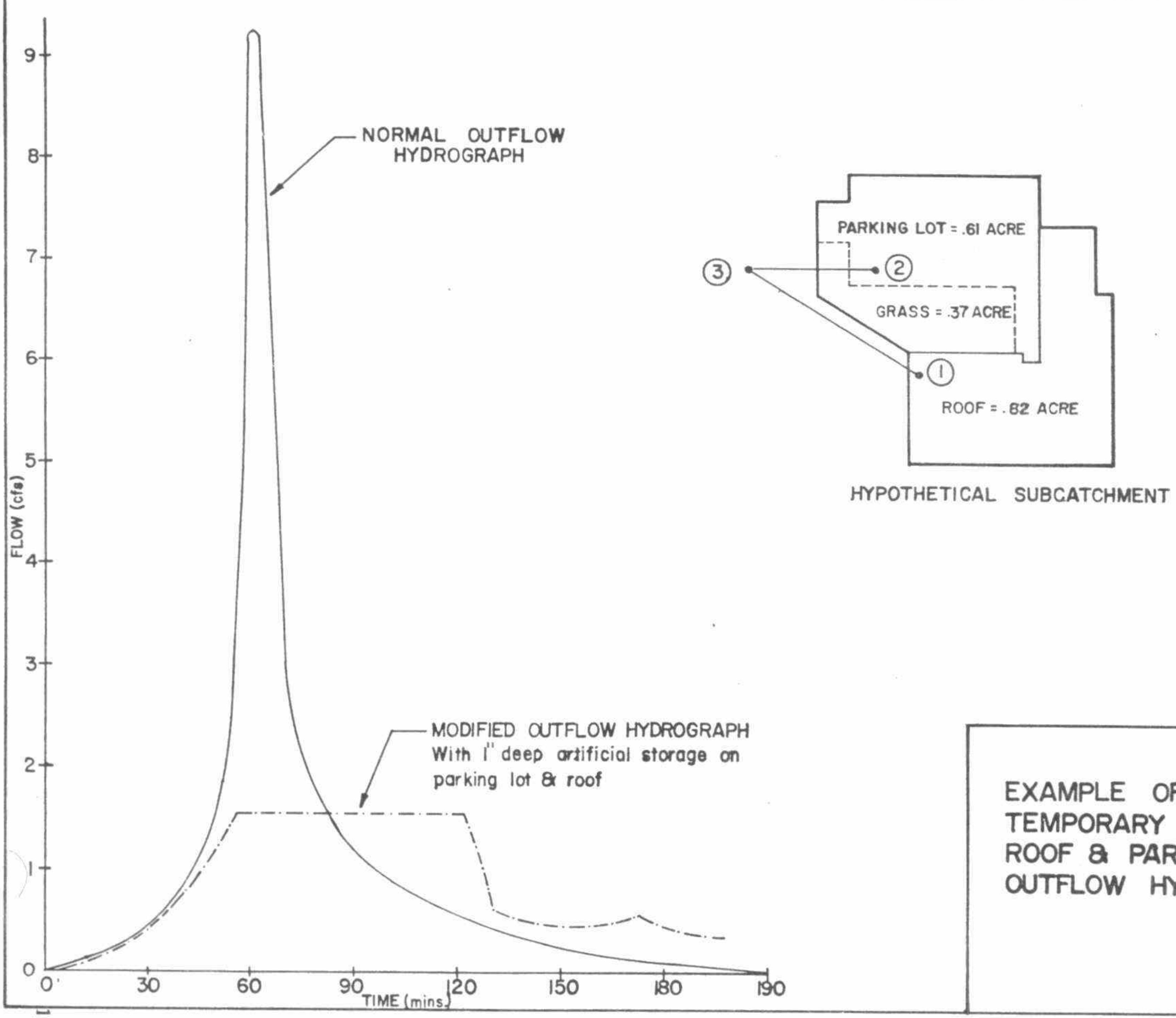
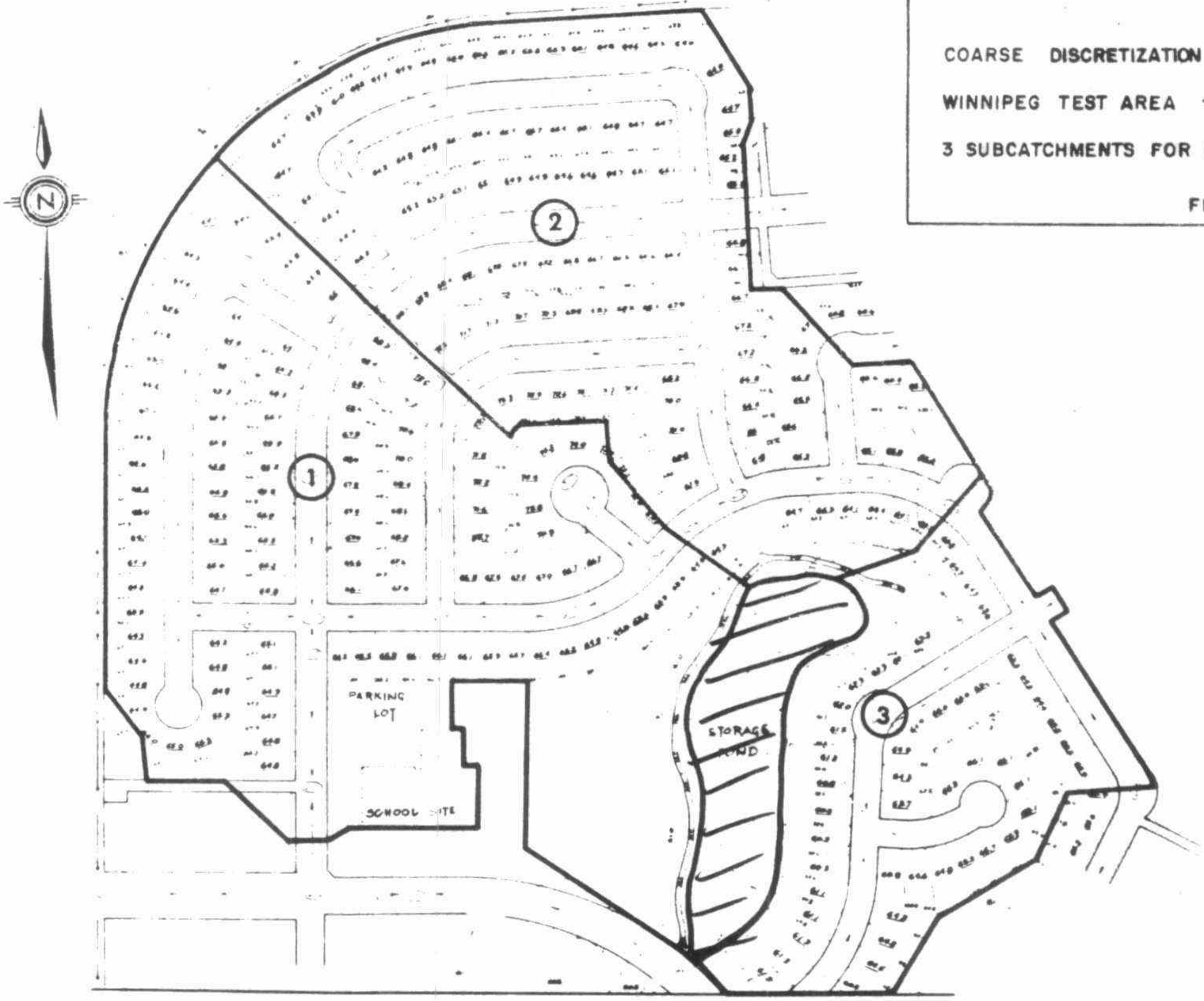


FIGURE 5. EFFECT OF CHANGED LAND USE ON CHARACTERISTICS OF SUBCATCHMENT RUNOFF, SELBY STREET



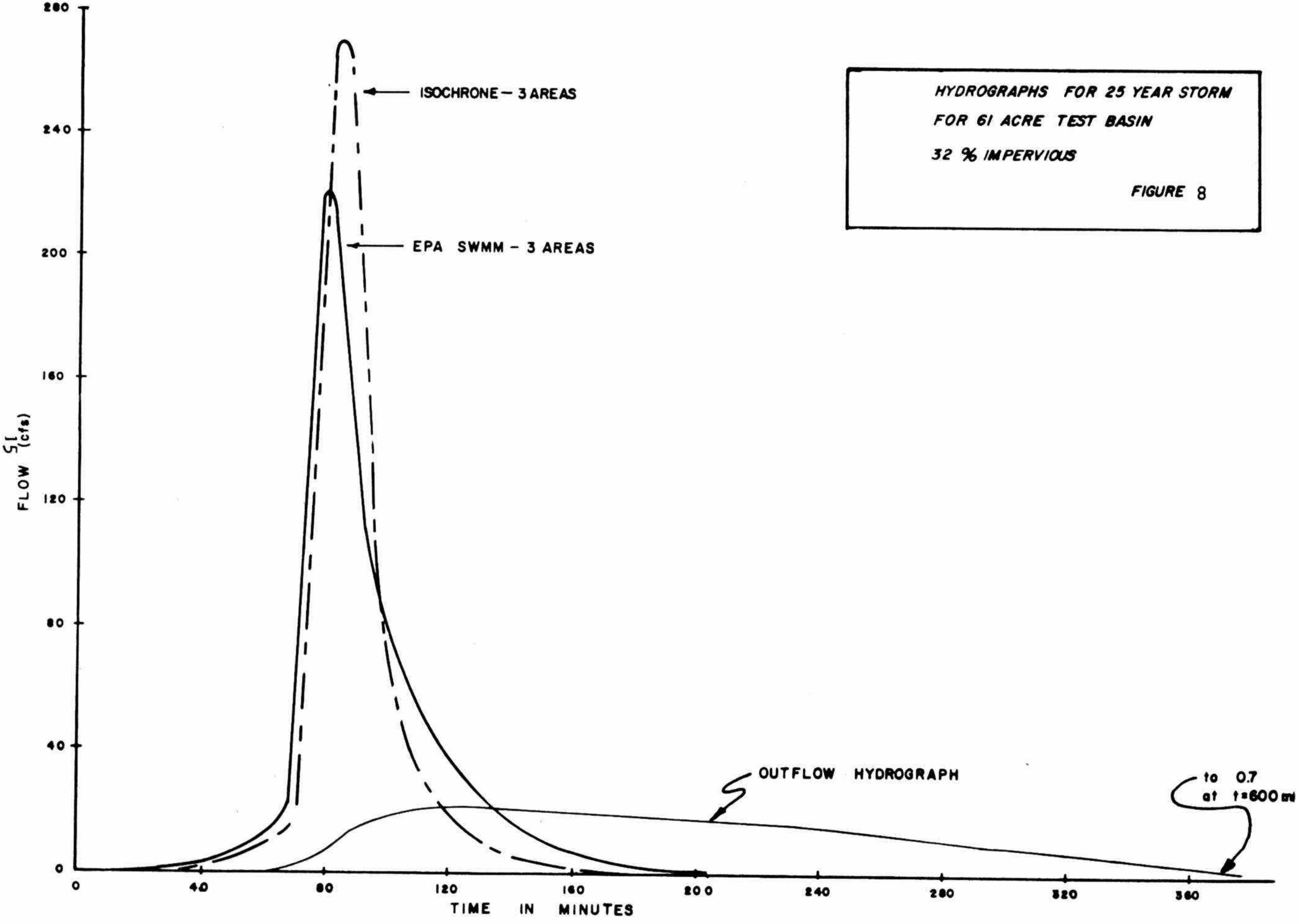
EXAMPLE OF EFFECT OF TEMPORARY PONDING ON ROOF & PARKING LOT ON OUTFLOW HYDROGRAPH

Fig. 6



COARSE DISCRETIZATION OF WINNIPEG TEST AREA — 3 SUBCATCHMENTS FOR EPA-SWMM

FIGURE - 7



HYDROGRAPHS FOR 25 YEAR STORM
FOR 61 ACRE TEST BASIN
32 % IMPERVIOUS

FIGURE 8

Selection of the optimum alternative for any situation is based on economics, maintenance, safety and other considerations. The effectiveness of a given alternative will depend on the specific aspects of the study area, so it is not possible to develop a general rating of the alternatives.

POLLUTION CONTROL FROM COMBINED SEWERS

The pollution resulting from combined sewage is a common problem for environmental engineers working in older cities. Combined sewers were built with the thought that dry weather flow could be economically carried to the interceptors and that infrequent overflows would be of short duration and sufficiently diluted so as not to pollute receiving waters. However, the growth and development of the urban centres and the increasing areas of impervious surface lead to an increased rate of overflow of polluted and untreated water during the runoff from major storms.

The problem is usually aggravated by the hydraulic inadequacy of the regulating devices, which have the function of controlling the portion of the flow allowed to enter the interceptor system and to direct the balance to nearby receiving water bodies and in some cases, to holding or treatment facilities. Most regulators in older sewer systems are of the static type with a lateral weir or orifice to relieve the system, and cannot be adjusted to meet various flow criteria. Furthermore, because of inadequate design or maintenance, effective control of the flow is not obtained with some dynamic regulators.

Total separation of storm runoff has sometimes been considered as a solution to the storm overflow problem. Its principal disadvantages are the tremendous cost and the disruption of traffic during construction, the reworking of houses and building plumbing and the impractability of avoiding illegal connections. For this reason and also because of an increased awareness about the quality of the storm water discharging into the receiving water bodies, other methods for abatement of the pollution due to combined sewage overflows have been recently considered. Such methods consider the use of the existing combined system with improvements leading to the reduction of overflow quantities and/or treatment of overflows.

Storage facilities of urban runoff have many favourable attributes such as their simplicity in design and operation, response without difficulty to intermittent and random storm behaviour, provision of flow equalization, etc. Frequently they can be operated in concert with regional dry-weather flow treatment plants. Design of storage facilities requires simulation of inflow hydrographs. Complete storage of a rare event such as a two or five-year storm is rarely economically justified and the best alternative is usually a combinadion of treatment and storage. Efficiency of storage is determined on the basis of a statistical analysis of the number and volume of overflows for different combinations. Antecedent conditions which may partly reduce the storage capacity have to be considered for each storm event. This information cannot be obtained by means of the Rational method, but is readily available by means of the models presented in this workshop. Examples of large scale combined sewer pollution abatement programs using storage are the underground storage system in Chicago and the multistorage system in San Francisco. Storage alternatives are examined considering flow handling, solids removal, protection against odours, etc.

Another method is "total system management" in which remote controlled dynamic devices can restrict the outflow by controlling the "traffic" of the combined flow. The objective is to optimize the containment and treatment of storm runoff with actions dependent upon storm pattern and treatment and availability of storage capacities. Such systems have been successfully implemented in Seattle, Minneapolis-St. Paul, Detroit, etc. The mid-Toronto interceptor has been equipped with dynamic gates and water level sensors, and future operation according to these principles has been considered. Real time control of these systems requires continuous modelling of runoff hydrographs, routing and overflows. Preliminary studies for the investigation of those alternatives also require modelling of overflows for past storm events.

Another alternative is the treatment of overflows. Conventional treatment is based on comparatively steady conditions. Flow and quality characteristics of urban runoff and overflows are subject to a high variability over a short period of time, a high debris content and high flow rates. As a first level, it was possible to successfully use specific devices such as swirl concentrators. More conventional screening/straining devices are described in another lecture. The cost of treatment facilities and that of associated storage facilities is highly dependent on flow simulation.

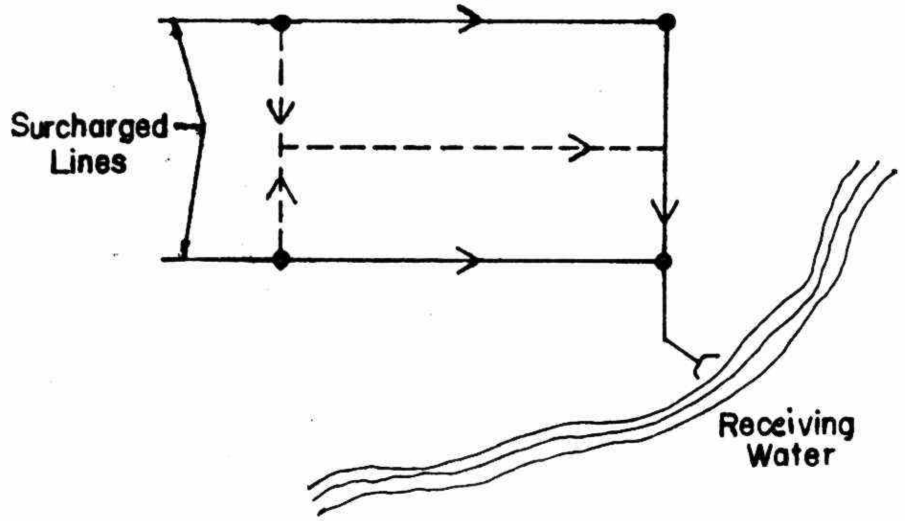
Decision-makers need information regarding inflow quantities and qualities, effects of treatment and last, but not least, effects in the receiving water bodies.

The U.S. EPA Storm Water Management Model was designed to provide this information. An excellent EPA film presenting all these aspects is available.

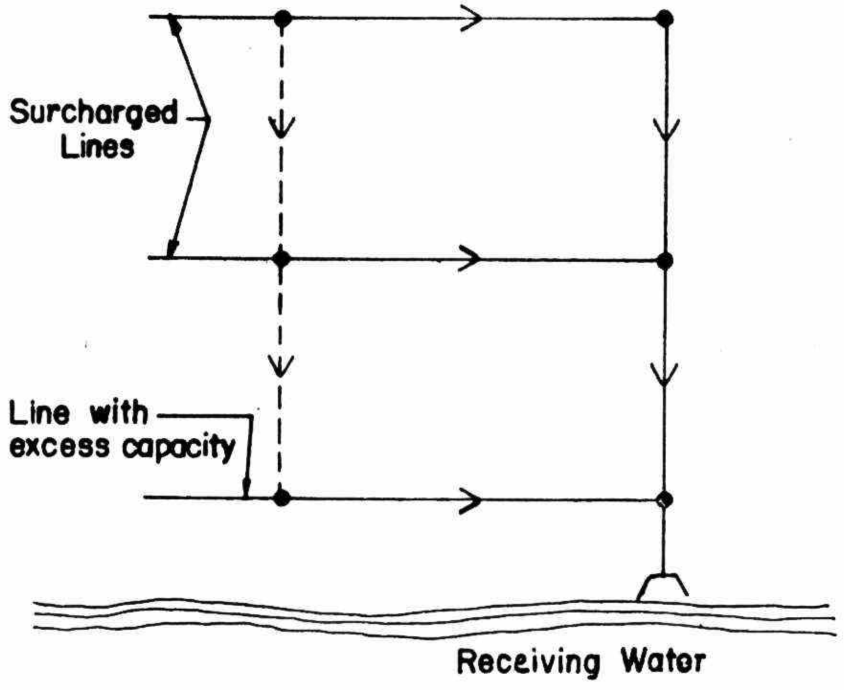
STORM AND RELIEF SEWERS

Many older municipalities experience flooding problems at some time. This condition may result from the collapse or obstruction of an old sewer line, originally inadequate design capacity, or poorly planned redevelopment or new development over the years. The factors and the increased use of basements as living space makes flooding a more serious problem today than it once was, demanding a greater degree of protection than in the past. The magnitude of the investment required for even a modest relief program, however, makes it imperative that all of the possible relief alternatives are investigated to arrive at the most economical solution.

Where a sewer line is greatly undersized, it may be necessary to install a parallel line to create sufficient capacity or, if a neighbouring line has excess capacity, some flow might be diverted to it from the overloaded sewer through a cut-off sewer (Figure 9). In any case, an accurate analysis must consider the capacity of the existing sewer and the effect of the interconnection between the existing sewer and relief sewer. The reduction of the peak inflow rate through the use of surface ponding and storage is also an important alternative. A small depth of temporary ponding can result in remarkable reductions in the peak inflow rate in some cases. However, in an existing development, there are often relatively few locations where increased surface detention is practical and storage facilities, which must be large to be economical, are both expensive and difficult to locate. The best solution in the end may be some combina-



PARALLEL RELIEF SEWER



CUT - OFF RELIEF SEWER

- - - - RELIEF SEWER

POSSIBLE RELIEF SEWER ALTERNATIVES

Fig. 9

tion of these alternatives. As demonstrated in many European cities, and Canadian cities such as Toronto, Winnipeg and Edmonton, a significant improvement can be achieved in both the cost and hydraulic efficiency of some sewer systems when a small degree of surcharge, limited to the requirements of increased in-system storage and flow redistribution, is considered for design loadings.

In the past, storm sewers were always designed for free surface flow. This was done for several reasons:

1) When design flows fell between two pipe sizes, the larger size was selected as a conservative approximation.

2) It was not possible to determine the real magnitude and distribution of any excess capacity. The Rational Method could not deal with the analysis of a complex sewer network in which both free surface and pressurized flow conditions occur in a partially looped, partially dendritic system.

3) Due to the uncertainty of the flow rate and the lack of accurate hydraulic routing in the design procedure, it was felt that the additional flow capacity of the system resulting from surcharge should be kept in reserve as an added factor of safety.

It is no longer necessary, however, to adhere to these restrictions. Many comparisons have been done between measurements and model computations, which demonstrate that inlet hydrographs predicted by calibrated models are close to the real flows. Models are also available for the accurate hydraulic analysis of surcharged conditions. If a factor of safety is desired, it can be incorporated into the design as a known function of the design rainfall rather than an indeterminate 'extra' resulting from the methodology.

The effect of surcharge on a sewer network is to cause a redistribution of flow from segments which are under pressure to those that are not by means of backwater effects and cross-over flows between interconnected pipes. This provides a certain amount of internal relief to the system by a more complete utilization of its potential storage and flow capacity.

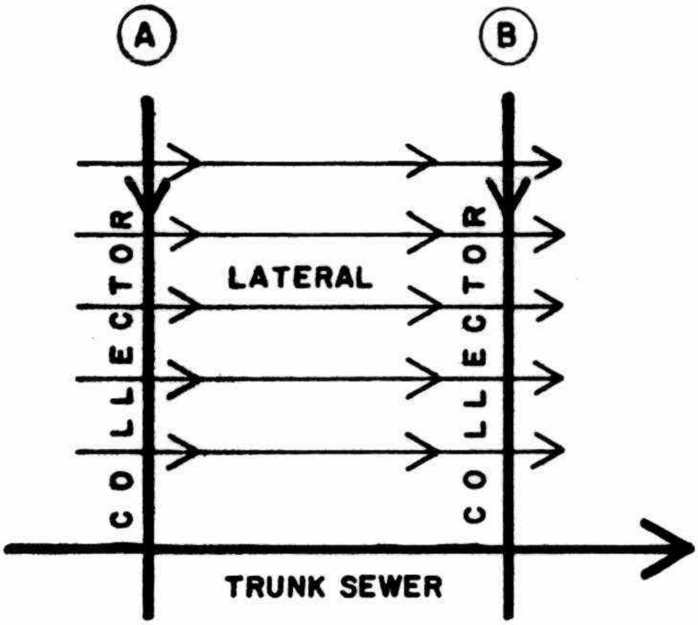
Figure 10 illustrates the possible difference between results obtained by analyzing a sewer network using a model that considers surcharge and one that does not. In this hypothetical example, when lines A and B are considered separately, line A is found to be flowing full and line B has a very high surcharge. When A and B are connected by the lateral pipes, however, flows are generated from line A to line B due to the difference in water levels which, in this case, is sufficiently high to overcome the adverse slope in the laterals. In the design of the system segment shown without surcharge, a significant increase in pipe size would be required online B, while the analysis with surcharge and cross-connections demonstrates that the existing pipe sizes are adequate in this case if a degree of surcharge is permissible.

The degree of surcharging required to relieve a system depends on several factors. The slope, depth and capacity of the conduits and the number and size of cross-connections will all have some effect. In general, however, it is apparent that significant economies may be possible if surcharge is considered in relief sewer design.

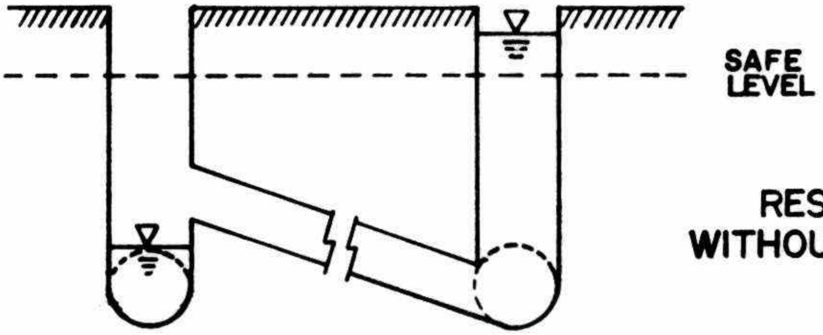
SELECTION OF MODELS

During both the planning and design stages, modelling should start after the objectives have been clarified, the alternatives or options determined and the criteria for their selection defined. The results of the modelling are used to assist in comparison and selection of alternatives. The real process, especially in the planning stage, is a circular one in which modelling assists the decision-maker in a better definition of his objectives.

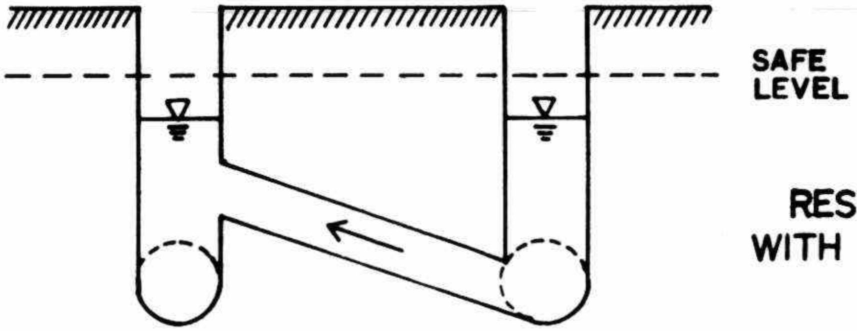
Models may be different for planning and design stages. For example in studies related to new developments during the planning stage, the decision-maker is more interested initially in the definition of problems and the screening of a broad range of alternatives. These alternatives may include not only types of storage, but also selection of the level of control or level of protection against flooding. A detailed description of the system to be studied is often not available at the planning stage. Cost estimates for screening need only be approximate, provided that ranking of alternatives is not distorted. The final ranking of alternatives may be in the form of matrices incorporating both engineering aspects and



PLAN OF SEWER SYSTEM



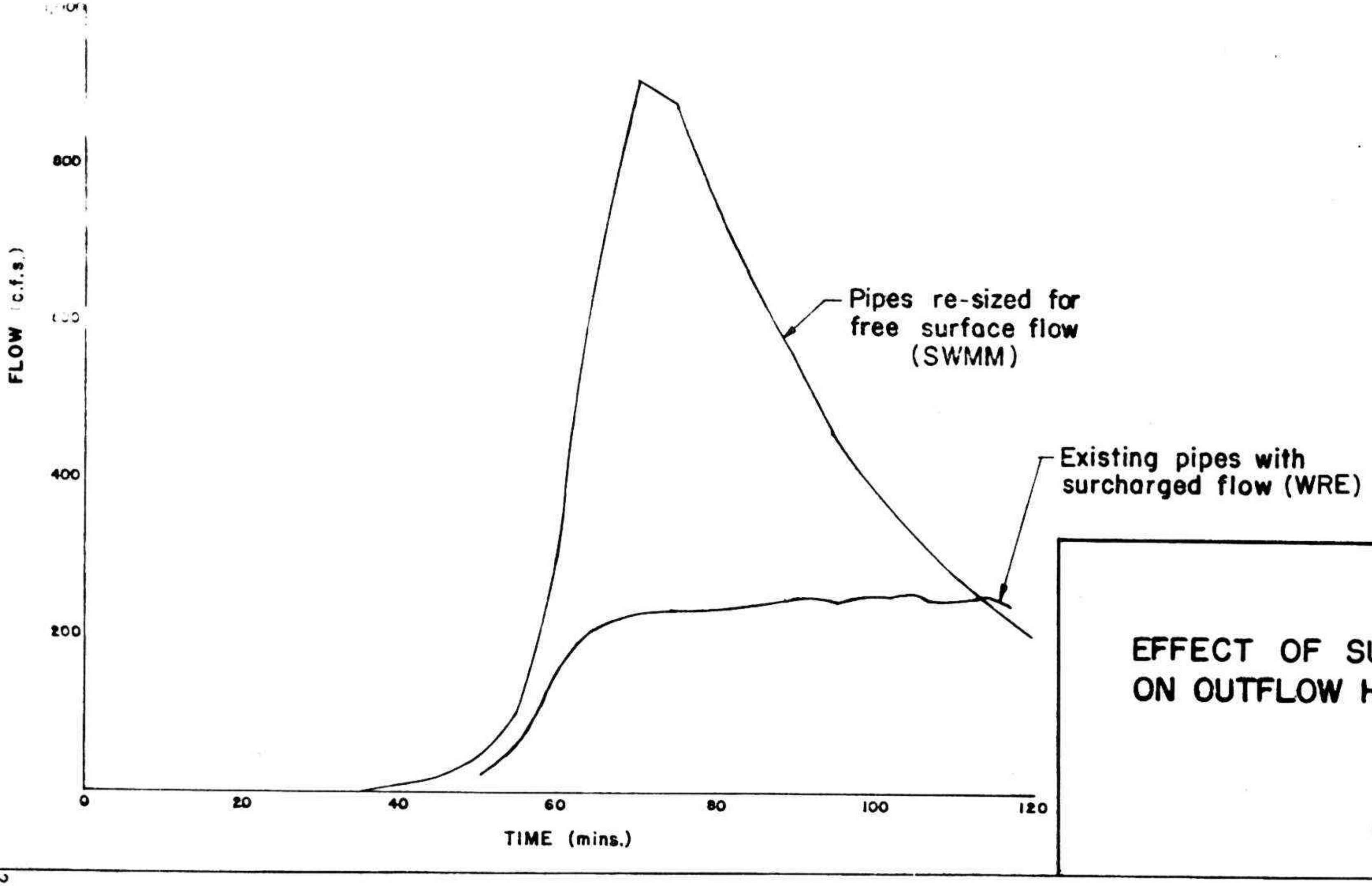
RESULTS OF ANALYSIS WITHOUT CROSS - CONNECTION



RESULTS OF ANALYSIS WITH CROSS- CONNECTION

EFFECT OF CROSS-CONNECTION IN SURCHARGED SYSTEM

Fig. 10



EFFECT OF SURCHARGE ON OUTFLOW HYDROGRAPH

Fig. 11

other considerations, for example, legal and social aspects, transportation and landuse policy.

When the alternatives have been narrowed down to a small number, accuracy and engineering become increasingly important. At the design stage, sophistication in approach may be justified by measurable savings in the investment. More data are usually available and the expenses for their collection are generally justified. At this stage, economics is often the key criterion for selection between alternatives.

An important rule concerning any model is that it has to be calibrated, validated and documented. The Rational formula cannot be calibrated because of its assumption of uniform rainfall intensity. The recent Canadian study on storm water management models was largely directed towards use of measurements on Canadian watersheds to validate catchment parameters which had been determined by calibration on U.S. watersheds.

Validity of the output from a model will be entirely dependent on the validity of assumptions and input data. (In the jargon of people who work with computers, GIGO means garbage in, garbage out).

Sensitivity analysis is a powerful tool in determining errors caused by some assumptions in modelling. The Canadian study included sensitivity analyses of such parameters as infiltration capacity and depression storage which could not be determined precisely by field measurements.

Many studies have compared models on the basis of their accuracy and some of these studies will be discussed in the lectures. It is felt that model selection should also be based on additional factors, including:

(a) availability in documented, non-proprietary form and potential for improvement through widespread use,
(b) low cost of data collection and operation,
(c) experience in practical applications and validation for Canadian conditions,
(d) simplicity - model sophistication compatible with complexity of problem to be analyzed.

In general, a single model cannot handle the whole range of questions which emerge during the course of a project. The modeller should be conversant with different types of models and capable of selecting the most appropriate models for different stages of the study. The "best" model is the one which gives the answers required for the decision-making process at minimum cost. Real cost includes also development of inhouse expertise, training, debugging of programs, availability of consultants, etc.

INTRODUCTION TO THE SWMM*

Alan R. Perks
Proctor & Redfern Limited

The SWMM is a comprehensive computer model used to simulate real or design storm events on an urban catchment. It accepts as input any rainfall pattern, and then makes a step by step computation of infiltration, depression storage, surface runoff and insewer routing to arrive at the desired outflow hydrograph. Hydrographs may be computed for any point in the sewer system. The model handles both the quantity and quality of storm water runoff from an urban area.

The program is comprised of four major computational blocks, each simulating a different part of the Rainfall/Runoff cycle.

RUNOFF BLOCK - simulates overland flow and surface runoff from a system of surface subcatchments.

TRANSPORT BLOCK - simulates in-sewer hydraulic routing and various sewer control structures.

STORAGE BLOCK - simulates any storage or treatment facility through which the runoff passes.

RECEIVING BLOCK - simulates the hydrodynamics of any lakes or streams into which the runoff is eventually discharged.

Each block is executed in the proper sequence; however, it is not necessary to operate the entire program in any simulation. In the majority of cases, only the RUNOFF and TRANSPORT blocks are run.

Large scale computer facilities are required, such as IBM 360, UNIVAC 1108, or CDC 6600, for running the SWMM. It is written in FORTRAN IV language. The cost of a simulation will vary depending upon the complexity of the system and the number of program blocks employed. Generally, a cost of about \$25 to \$50 results from a surface runoff and flow routing simulation employing some 150 manholes and pipes. Use of the new surcharged flow routines calls for smaller computational time steps which push the cost to $100 to $200 per run.

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* Refer to "Storm Water Management Model Study", Volume I, Sections 1, 4, 6 and 7, Canada-Ontario Agreement Research Report No. 47.

The SWMM was developed originally in 1971 by a consortium under the U.S. Environmental Protection Agency. It has since been modified and maintained by the University of Flordia. In Canada, Fisheries and Environment Canada and the Ontario Ministry of the Environment commissioned a study of the SWMM which had as its objectives a review of SWMM, addition of a Snowmelt model, provision of a complementary "planning" model, and development of separate routines for manipulating the modelling data. This study was conducted jointly by Proctor & Redfern Limited and James F. MacLaren Limited*

THE RUNOFF BLOCK

The RUNOFF Block computes storm water runoff quantity and quality characteristics from each surface subcatchment, and then stores the hydrographs and "pollutographs", which are essentially hydrographs of pollutant concentrations, at designated inlet points to the main sewer system.

This block is concerned exclusively with the surface runoff hydrographs before the main sewer system is reached. Each subcatchment is described in terms of its imperviousness, infiltration capacity, land use, average ground slope, detention storage capacity and surface roughness characteristics. The amount of impervious area has proven to be the most influential parameter on surface runoff. The greater the imperviousness, of course, the greater the peak flow rate and volume of runoff.

The amount of pollutants entering the storm water is computed as a function of the pre-storm accumulation of dust and dirt and the intensity of surface runoff. An exponential relationship is used to compute the dust and dirt washoff in each time step, based upon the computed rate of runoff. Seven types of pollutants are modelled and their concentrations are determined as fractions of the amount of dust and dirt washoff.

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* Refer to "Storm Water Management Study", Volumes I, II, and III, Canada-Ontario Agreement Research Reports No. 47, 48 and 62.

Hydrographs and pollutographs from each subcatchment are subsequently used as input to the routing procedures of the TRANSPORT block. Up to 200 subcatchments may be modelled in the program. The amount of input data depends upon the level of detail employed in the simulation.

THE TRANSPORT BLOCK

The TRANSPORT block simulates the routing of water and pollutants through the sewer system to the outlet. Input consists of the inlet hydrographs and pollutographs generated in the previous block. The geometric properties of the sewer system are described to the program, which then sequentially combines the inlet hydrograph with the conduit flows and routes the resulting flow downstream to the next manhole.

Dry weather flow and infiltration are also computed here. Using various combinations of these capabilities, SWMM can be used to simulate storm or combined sewers.

Various pipe shapes and structures may be modelled to more closely represent the real system, including in-line storage devices. Up to 160 conduits and manholes may be modelled in a single run. In order to accommodate larger systems, however, it is usually necessary to aggregate several small conduits into a single representative large conduit.

SWMM employs the "kinematic wave" theory, in accordance with Manning's equation and continuity, for the routing of flows under free-surface conditions. When pipe capacity is exceeded, however, the program limits the flow to that capacity, and stores the excess flow for subsequent release when capacity becomes available. More recently, new routines have been developed which simulate conditions during surcharging and account for the hydraulic grade elevation at all times. Flooding and increased capacities under surcharge may be investigated more fully using these routines.

Quality constituent routing from manhole to manhole is basically by a mass balance approach. This means that pollutants entering the sewer system at each manhole are combined with the sewer flows from upstream areas and new concentrations are computed.

Routed in-sewer hydrographs and pollutographs may be printed out for any point in the system. Results for the outlet point may be passed on to subsequent STORAGE or RECEIVING blocks.

THE STORAGE-TREATMENT BLOCK

This block models the effects of off-line storage units and/or storm water treatment operations. In addition, cost estimates for installation and operating the treatment processes being modelled may be computed. This block accepts as input the outlet hydrographs and pollutographs generated by the TRANSPORT block.

Storage units are modelled according to the desired volume, geometric properties, and outflow controls. Both irregular and regular shaped units may be simulated, and the selected outlet or inlet controls may consist of weirs, pumps or orifices. Sedimentation is modelled as a function of detention time. This flexibility permits application to a wide range of actual costs.

Treatment is modelled by selecting combinations of standard treatment processes which are contained in the model. Strings of individual processes are thus made up representing the desired overall treatment package. In each time step, solids and BOD removals are computed according to the selected string.

Storage and treatment costs may be estimated for each configuration of units modelled. Capital and operating costs for installation, land, chemicals, etc., may be computed from input unit costs and indices.

Only minimal input data is required to describe the storage/ treatment facilities.

THE RECEIVING WATER BLOCK

The RECEIVING block models the impact of storm and combined sewer discharges on lakes, rivers, and estuaries. Aside from in-sewer hydraulic and control problems, this is the other major reason why we are concerned about storm water in urban areas. The receiving water body possesses a certain assimulative capacity, depending upon its size, temperature, and configuration. To properly decide upon the allocation of this assimilative capacity, the effects of various alternatives must be investigated.

Usually the most important way in which pollutants move about in smaller water bodies is by the bulk movement of the water itself.

Therefore, the determination of the flow patterns is also required, and for this, the RECEIVING block was developed

The RECEIVING block uses a system of "channels" and "nodes" to represent a water body. Nodes are assigned a volume, surface area, and depth, representing a small portion of the water body. Channels, having a certain length, width, slope, and roughness, are used to connect the nodes.

The equations of motion and continuity are solved at each time step to determine the flow in each channel and the net transfer from node to node. Resulting changes in the water surface elevation are computed at each node. The conservation of mass is used to determine changes in pollutant concentrations at nodes.

Various boundary conditions such as a tidal curve, weirs, or a specified outflow may be simulated.

The RECEIVING block model is one dimensional, and will be sufficiently accurate for a large number of rivers, lakes, and estuaries where this assumption is valid. Where pollutant movement is not primarily by bulk movement of water, then the model should not be used.

MODEL USAGE

The foregoing brief overview was intended to illustrate the broad scope of the entire SWMM and also to indicate the basic mechanics of its operation. In fact, the RUNOFF and TRANSPORT blocks have become the most widely used of the four major computational blocks, and are often run by themselves. Let's now look at the steps required in performing a typical simulation using these two blocks.

Certain basic data must first be collected and reviewed. Topographic and land use plans are required to describe the surface subcatchment characteristics. Information on soil types is useful, although default values for this parameter, as well as surface detention, and surface roughness are provided. Sewer system maps, plans and profiles are required in order to properly describe each conduit being simulated. Inspection of this data may reveal serious inadequacies which would require some field work.

Unless very small systems are being modelled, skeletonizing the sewer system into its major elements will be the next step. All major trunk conduits, and pipes serving areas of special interest should be included up to the limit of 160 elements. Aggregating several small pipes into a representative large one for modelling purposes is acceptable.

The surface of the drainage area must then be subdivided into tributary subcatchments draining to each inlet manhole being simulated. Ideally, the subcatchments should represent homogeneous land uses, and several subcatchments may be assigned to a single manhole. For each subcatchment, representative infiltration, detention, slope and roughness parameters must be defined.

Detailed instructions on these procedures are given in the SWMM User's Manuals. The data is then coded and keypunched into a card deck which is used to run the SWMM. Once several runs have been modelled, the user will usually obtain some familiarity with the model and its output, and be in a position to operate the numerous graphical, printout, and execution control options.

MODEL CALIBRATION

Model calibration should be carried out, where possible, to ensure that the model is accurately simulating the characteristics of the real system. It may be conducted using all or only a portion of the area under study. The basic procedure consists of a comparison between measured and SWMM computed hydrographs at the same point in the system. Subsequent adjustment of some of the model parameters may be done to improve the agreement between model and measurements.

Most of the parameters useful for calibration are in the RUNOFF block, and consist of infiltration rates, detention storage, resistance factors, and to a certain extent, imperviousness. Each of these parameters will influence either the peak flow, volume, shape, or timing of the resulting hydrograph. There are no set rules as to which parameters should be adjusted in any situation; however, experience has shown that the imperviousness and infiltration rates are the most influential ones. The following table shows these parameters and the characteristics of the hydrographs most affected.

Parameter	Has Most Effect on
Percent imperviousness	Peak flow, volume
Infiltration rates	Volume, peak flow
Detention storage	Volume
Roughness factors	Timing

Calibration may also be conducted for the quality simulation, although a good agreement is difficult to obtain over more than a single event.

An appreciation of the sensitivity of the model to changes in the input parameters is useful in conducting a calibration. Experience in running the model is the best instructor in this regard.

THE SWMM RUNOFF SUBMODEL - RELATIONSHIPS FOR QUANTITY SIMULATION

Bill Clark
James F. MacLaren Limited

1. RUNOFF PHENOMENA - HYDROLOGIC AND HYDRAULIC PROCESS

- Runoff from urban watersheds generally involves the interaction of many phenomena varying both temporally and spatially.
- Hydrologic processes:
  - rainfall intensity,
  - evaporation losses,
  - interception,
  - depression storage losses,
  - surface infiltration losses,
  - overland flow over pervious and impervious surfaces.
- Hydraulic processes:
  - lateral inflow to gutter systems,
  - flow routing through shallow gutters,
  - inflow through catch basin grates,
  - conduit flow.

2. PREVIOUS METHODS OF ANALYSIS

- Many attempts to simplify these phenomena have been made in pre-computer era. Of these, the Rational method is by far the most widely used.
- The Rational method is technically inadequate for many modern requirements of storm water management.

3. UNIT HYDROGRAPH METHODS

- Unit hydrograph methods are widely used in rural watersheds and they give good results if adequately calibrated.
- Many attempts have been made to apply the unit hydrograph approach to urban watersheds (QUURM is a Canadian example).

In general, calibration against measurements is carried out by adjustment of the imperviousness ratio and sewer characteristics.

- Measurements may be used in future research and unit hydrograph development when they are available.
- Measurements in Texas show that unit hydrograph characteristics change drastically with surcharge.

4. ISOCHRONE METHODS

- The isochrone method is a simple procedure to generate hydrographs. The approach was improved by the Road Research Laboratory in Great Britain (RRL Model) and more recently by the Illinois State Water Survey (ILLUDAS Model)
- This method uses a less sophisticated transport routine than SWMM.

5. SCHEMATIZATION OF THE URBAN WATERSHED IN THE SWMM

- SWMM separates the analysis of the urban drainage system into the hydrologic (watershed) processes and the hydraulic (conduit) processes and two independent but interfaced program blocks are used (RUNOFF and TRANSPORT). Only RUNOFF is discussed here.
- Even with a computer technique it is still necessary to greatly simplify the representation of the watershed, although most of the important hydrologic processes are represented, i.e.
  - rainfall intensity variation,
  - depression storage,
  - surface infiltration,
  - overland flow,
  - gutter and conduit flow.
- SWMM model makes many simplifying assumptions on each subwatershed.
  - Each subwatershed is comprised of rectangular plane surfaces.
  - The subwatershed can be divided into one completely pervious block and one completely impervious block.
  - Rainfall is uniform over whole area for each time interval.
  - Infiltration rates are independent of rainfall intensity or antecedent volume and do not recover with time.

  - All runoff enters the gutter or inlet at a single point.
  - Depression storage on pervious areas is not restored by infiltration.
  - Surface conditions (slope, roughness, etc.) are uniform.
  - Simplified "volumetric" gutter routing.
- Because of all these approximations, runoff hydrographs are usually the major source of error in the model simulation. More detail (smaller subwatersheds) improves accuracy, but cost of data preparation, computer runs, etc., goes up.
- Testing results show that these approximations still give good results. Despite limitations, the model does account for physical processes and watershed response to different factors.

6. SWMM SIMULATION PROCESS

- Step by step procedure given in the handout at the back of these notes.

7. DESIGN STORM CONCEPT*

- Historical rainfall data (intensity - duration curve) is used to derive a theoretical rainfall distribution. (See attached figure). A statistical analysis of many rainfall events is used to derive the characteristics of the hyetograph.
- For any given duration, the maximum average intensity equals that of the intensity duration curve of the same frequency.
- Eventually storms of record may be used if measurements are maintained on large urban watersheds.

8. SWMM RUNOFF INPUT REQUIREMENTS

a. Rainfall hyetograph

b. Subcatchment areas

c. Subcatchment % imperviousness

d. Subcatchment depression depths

e. Subcatchment infiltration rates

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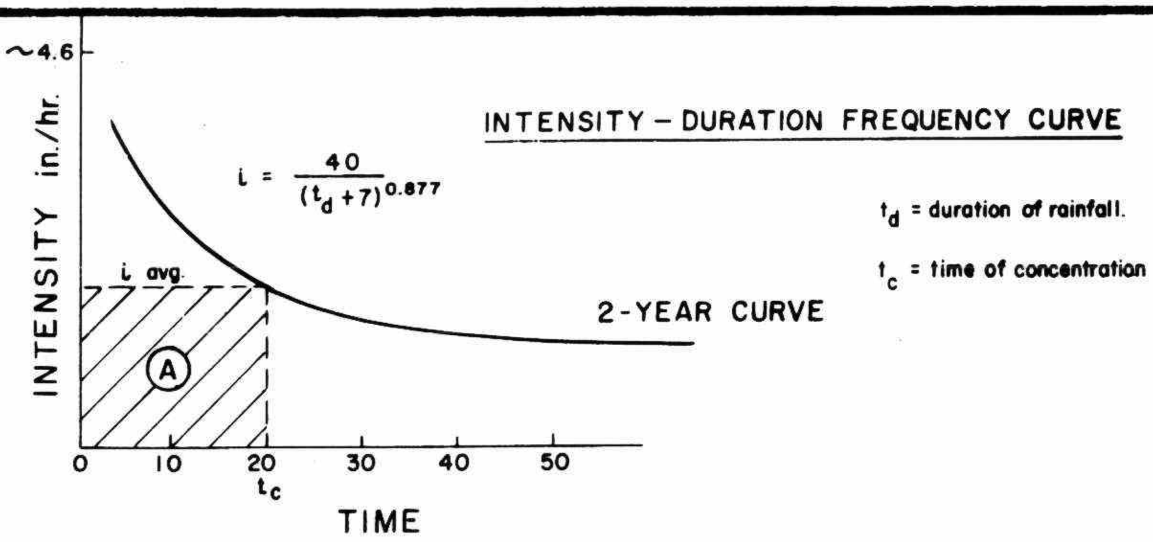
* Reference: Kiefer, C.J. and Chu, H.H. "Synthetic Storm Pattern for Drainage Design", ASCE Journal Hydraulics Division, August, 1957.

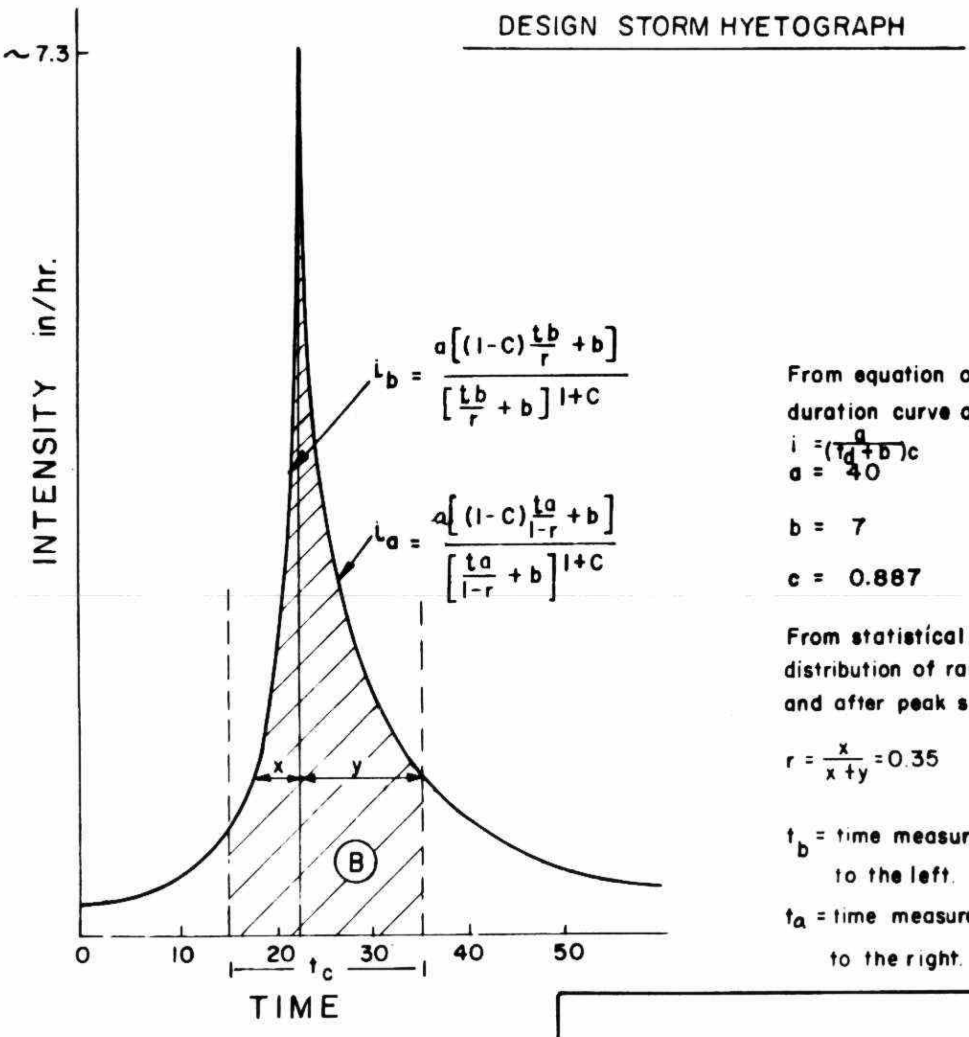


INTENSITY – DURATION FREQUENCY CURVE

$$i = \frac{40}{(t_d + 7)^{0.877}}$$

t_d = duration of rainfall.

t_c = time of concentration



DESIGN STORM HYETOGRAPH

$$i_b = \frac{a\left[(1-C)\frac{t_b}{r} + b\right]}{\left[\frac{t_b}{r} + b\right]^{1+C}}$$

$$i_a = \frac{a\left[(1-C)\frac{t_a}{1-r} + b\right]}{\left[\frac{t_a}{1-r} + b\right]^{1+C}}$$

From equation of intensity-duration curve of form

$i = \frac{a}{(t_d + b)^c}$

a = 40

b = 7

c = 0.887

From statistical analysis of distribution of rainfall before and after peak storm intensities.

$r = \frac{x}{x+y} = 0.35$

t_b = time measured from the peak time to the left.

t_a = time measured from the peak time to the right.

VOLUME Ⓐ = VOLUME Ⓑ

DERIVATION OF 2 YEAR DESIGN STORM FROM INTENSITY – DURATION FREQUENCY CURVE

f. Subcatchment geometry (width)

g. Subcatchment slope

h. Subcatchment roughness

i. Gutter/pipe characteristics

j. Control parameters - number of timesteps, computational time interval, etc.

EQUATIONS OF EPA RUNOFF MODEL

1. Rainfall is added to the subcatchment according to the specified hyetograph:

$$D_1 = D_t + R_t \Delta t \text{.......................................} (1)$$

in which D_1 = the water depth after rainfall: D_t = water depth of the subcatchment at time t; and R_t = the intensity of rainfall in time interval Δt.

2. Infiltration I_t is computed by Horton's exponential function, $I_t = f_o + (f_1 - f_o) e^{-at}$, and is subtracted from water depth existing on the subcatchment

$$D_2 = D_1 - I_t \Delta t \text{.......................................} (2)$$

in which f_o, f_1, and a = coefficients in Morton's equation and D_2 = intermediate water depth after accounting for infiltration.

3. If the resulting water depth of the subcatchment D_2 is larger than the specified detention depth D_d, and outflow rate is computed using Manning's equation:

$$V = \frac{1.49}{n} (D_2 - D_d)^{2/3} S^{1/2} \text{...................................} (3)$$

$$\text{and } Q_w = V\,W\,(D_2 - D_d) \text{...} (4)$$

in which V = the velocity; n = Manning's coefficient; S = the ground slope; W = the width; and Q_w = the outflow rate.

4. The continuity equation is solved to determine the water depth of the subcatchments, resulting from the rainfall, infiltration and outflow. Thus

$$D_t + \Delta t = D_2 - \frac{Qw}{A} \Delta t \text{..................................} (5)$$

in which A = the surface area of the subcatchment.

5. Steps 1 to 4 are repeated until computations for all subcatchments are completed.

6. The inflow (Q_{in}) to a gutter is computed as a summation of outflow from tributary subcatchments ($Q_{w,i}$) and flow rate of immediate upstream gutters ($Q_{g,i}$)

$$Q_{in} = Q_{w,i} + \Sigma Q_{g,i} \quad \text{.......} (6)$$

7. The inflow is added to raise the existing water depth of the gutter according to its geometry. Thus

$$Y_1 = Y_t + \frac{Q_{in}}{A_s} \Delta t \quad \text{.......} (7)$$

in which Y_1 and Y_t = the water depth of the gutter and A_s = the mean water surface area between Y_1 and Y_t.

8. The outflow is calculated for the gutter using Manning's equation:

$$V = \frac{1.49}{n} R^{2/3} S_i^{1/2} \quad \text{.......} (8)$$

and $Q_g = V A_c$ .... (9)

in which R = the hydraulic radius; S_i = the invert slope; and A_c = the crosssectional area at Y_1.

9. The continuity equation is solved to determine the water depth of the gutter, resulting from the inflow and outflow. Thus:

$$Y_t + \Delta t = Y_1 + (Q_{in} - Q_g) \frac{\Delta t}{A_s} \quad \text{.......} (10)$$

10. Steps 6 to 9 are repeated until all the gutters are finished.

11. The flows reaching the point concerned are added to produce a hydrograph coordinate along the time axis.

12. The processes from 1 to 11 are repeated in succeeding time periods until the complete hydrograph is computed.

THE SWMM RUNOFF SUBMODEL - RELATIONSHIPS FOR QUALITY SIMULATION*

Andy F. Roake
James F. MacLaren Limited

1. BACKGROUND

- The most significant effect of the trend towards sewer separation in the 1960's is that combined sewers are not normally installed in new developments.
- About 50% of Canada's urban areas are still served by combined systems.
- Within the last 20 years, the significance of pollutants in urban runoff has been recognized.
- Pollutant concentrations in surface runoff measured in North York, Toronto in a single-family residential subdivision:

SS	15 - 410 mg/l
BOD_5	1 - 90 mg/l
Total Coliform	2800 - 110000 MPN/100 ml
Phenols	0 - 22 ppb

2. POLLUTANT LOADS

- Once depression and infiltration losses are accounted for, 0.10 inches of rain over a 1000-acre subdivision will cause about

$$1000 \text{ (acres)} \times 43560 \text{ (ft}^2\text{/acre)} \times \frac{0.10 \text{ (in)}}{12 \text{ (in/ft)}}$$

$$\times\ 40 \text{ (percent imperviousness)}$$
$$\simeq 150{,}000 \text{ ft}^3 \text{ of runoff.}$$

- BOD_5 concentrations in surface runoff are often comparable with those in secondary effluent at the treatment plant.

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* Refer to "Storm Water Management Model Study", Volume I, Section 5, and Volume II, Sections 2 and 3, Canada-Ontario Agreement Research Reports No. 47 and 48.

SS concentrations are often comparable with those in raw domestic sewage.

- The volumes of surface runoff in a medium intensity storm in an urban area may be 100 times the dry weather flow (DWF) from that area. Consequently, during storms the total pollutant load,

  i.e. runoff volume (ft^3) x pollutant concentrations (mg/l)

  $$\times \frac{28.3\ (lb/ft^3)}{454\ (g/lb) \times 1000\ (mg/g)}$$

  to the receiving water via runoff can be many times that from the treatment plant.

- Combined sewer overflows are a mixture of polluted surface runoff and raw sewage. Therefore, in general, pollutant concentrations in overflows are higher than those in surface runoff.

- Some recent figures on the relative importance of urban pollutants show:

	Pounds per year per tributary acre	
Source [1]	BOD	SS
Treatment plant		
- primary treatment	1200	750
- secondary "	275	275
Combined Overflows	160	610
Surface Runoff	40	600

3. POLLUTANT SOURCES

Surface:

- washout of particulates and gases in the air
- dirty roofs and building surfaces
- dust and dirt on roads and sidewalks
- traffic byproducts (tire residuals, exhausts)
- animal droppings, vegetation
- fertilizers, weed killers

- de-icing agents
- erosion in new developments and parks

Subsurface:

- catch basins
- depositions from DWF in sanitary systems
- illegal cross-connections in separate sewers

4. STUDIES

- One of the most comprehensive investigations into surface pollutant sources was conducted by APWA in Chicago. In was apparent that the most significant component of street refuse is dust and dirt (except in the fall when vegetation is predominant) [2].

Rags	0.018 ton/month
Paper	0.432
Dust/Dirt	6.60
Vegetation	2.22
Inorganics	1.08
Total	10.35

- The major problem with storm runoff monitoring studies is that average concentrations are often reported instead of total event pollutant loads and consequently comparison with other studies is not possible.

- The need for consistent units has led to the development of:

  mg of pollutant per g of dust and dirt,

  and lbs of dust and dirt per 100 feet of gutter per day,

  for the composition and accumulation rate (respectively) of surface pollutants.

- Studies in Chicago and Tulsa have indicated that the rate of accumulation of pollutants on an urban watershed varies significantly with land use. Industrial and commercial areas tend to be much dirtier than residential areas.

- While the rate of dust and dirt accumulation appears to be consistent, specific local circumstances may greatly alter composition (de-icing chemical is an example).

5. ENTRY OF POLLUTANTS INTO SURFACE RUNOFF

- Initially pollutants are washed out of the air. Depressions in the impervious area are filled, runoff from impervious area begins, surface pollutants are dissolved, or as the runoff intensity increases, are suspended. The rate of runoff controls the size of the particles picked up in the flow.

6. MODELLING THE QUALITY OF URBAN RUNOFF

- There are both statistical and deterministic models available for modelling runoff quality.
- Statistical models for runoff quality are often based on multiple regression equations of the form:

$$Y_p = bo + b_1x_1 + b_2x_2 + b_3x_3 + \ldots . b_kx_k + u$$

where: Y_p is the independent variable,

x_i (i = 1 to k) represents an explanatory variable,

b_i (i = 1 to k) represents a regression coefficient, and

u is an unexplained residual term.

In this case, the Y_p's are the pollutant concentrations, and the x_i's are the independent variables which define precipitation characteristics. The precipitation characteristics may be divided into two groups:

1) Current Event

x_1 = time since start (min.)
x_2 = total amount since start
x_3 = average intensity (in/hr)

2) Antecedent Event

x_4 = time since antecedent event (hr)
x_5 = amount of antecedent event (in)
x_6 = duration of antecedent event (hr)
x_7 = average intensity of antecedent event (in/hr)

- Statistical models can give reasonable predictions of pollutant concentrations when used within the range of variables (x_i) used to set up the regression equations.
- They do not perform well outside these ranges. Often we are interested in critical conditions, such as a heavy storm following a long dry spell. If we have already measured these conditions, simulation may not be required. If critical conditions do not fall within the sampled events, we cannot rely on the results of the regression equations.
- Statistical equations developed in one area have little relevance in other dissimilar areas. This is also true for an area undergoing a significant transformation such as urbanization.
- Deterministic models represent the physical and chemical phenomena involved in pollutant washoff. The model can only be as good as the understanding of these phenomena and the ability to reduce this understanding to mathematical relationships.
- Many simplifying assumptions are required for most models and generally only the major processes are modelled. Sometimes two or more processes are lumped as a single process. For instance, in SWMM there is no direct consideration of airborne pollutants. However, in calibration, they are indirectly considered as part of the surface accumulation.
- Some parts of the overall pollutant washoff phenomena may be well represented by statistically developed data, e.g. average pollutant levels in dust and dirt. Often, such parameters are incorporated in the model and it is no longer purely a deterministic model.

- SWMM and STORM are basically deterministic models but they contain a number of empirical parameters, especially in the quality routines.

- In general, deterministic models have a greater "transferability" to other watersheds than statistical models. This is because the main basic processes are accounted for.

- SWMM and STORM use basically the same equations for quality simulations.

  Using APWA units for the rate of dust and dirt accumulation, the rate of buildup DD_L for a given land use L can be expressed as:

$$DD_L = dd_L \times (G_L/100) \times A_L \tag{1}$$

where: DD_L = rate of dust and dirt accumulation on a watershed of land use L in lb/day;

dd_L = rate of dust and dirt accumulation on watershed L in lb/day/100 feet of gutter;

G_L = feet of gutter per acre in watershed L; and

A_L = area of watershed L in acres, and modified by any street cleaning.

- The initial quantity of a pollutant p on watershed L at the beginning of a storm can then be computed as:

$$P_p = (F_p \times DD_L \times N_D) + P_{po} \tag{2}$$

where: P_p = total pounds of pollutant p on the watershed L at the beginning of the storm;

F_p = pounds of pollutant p per pound of dust and dirt;

N_D = number of dry days since the last storm, and

P_{po} = total pounds of pollutant remaining on watershed L at the end of the last storm.

7. EXPONENTIAL WASHOFF EQUATION

- The mass, P, of a pollutant washed off in any time interval, dt, is proportional to the pounds on the land surface at the beginning of that time interval. This can be written:

$$\frac{-dP}{dt} = kP \qquad (3)$$

which integrates to

$$\Delta P = P_o \ (i-e^{-k\Delta t}) \qquad (4)$$

where: Δt is the pollutant mass washed off by surface runoff,

P_o is the initial surface pollutant mass,

t is time,

k is a constant (discussed below).

- The assumption was made that:

k varies directly with the rate of runoff, r, i.e. as k (=Br) becomes very large,

$$(1-e^{-k\Delta t}) \rightarrow \text{unity}$$

.˙. all surface pollutants would be removed at high runoff rates.

As a working hypothesis, it was assumed that a uniform runoff of 0.5 inches/hr would wash away 90% of surface pollutants in one hour.

This leads to a value of B = 4.6 and equation (2) becomes

$$\Delta P = P_o \ (1-e^{-4.6r\Delta t}) \qquad (5)$$

where: ΔP, P_o are in lb,

r is in inches/hour,

Δt is in hours.

Equation (5) is known as the exponential washoff equation and is the basis for SWMM quality simulations. In the model it is solved at each time step (typically 5 minutes).

A plot of ΔP versus t is termed a pollutograph, one of the most informative methods for expressing the pollutant load carried by urban runoff. To determine the concentration of a pollutant in the runoff as a function of time, one simply divides the pollutograph value, ΔP by Q (with appropriate conversion factors).

REFERENCES

1. Waller D.H., "Urban Drainage Problems and Possibilities", Paper presented at the annual conference of the Federation of Associations on the Canadian Environment, Toronto, April 21, 1975.

2. American Public Works Association, "Water Pollution Aspects of Urban Runoff", Water Pollution Control Research Series, FWPCA Report No. WP-20-15, January 1969.

THE SWMM TRANSPORT SUBMODEL

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1. PRINCIPLES OF SWMM RUNOFF SIMULATION

- SWMM RUNOFF generates surface runoff hydrographs and routes them through the local drainage system.
- SWMM TRANSPORT then routes the hydrographs through the main drainage network (trunk sewer system). If quality simulation is carried out, pollutographs are also routed through the network.

2. METHODS FOR FLOW ROUTING

- Steady flow routing methods merely transpose inflow hydrographs and may lead to significant errors for large drainage systems.
- Unsteady flow methods account for dynamics of sewer flow and in-system storage which modify the inlet hydrograph.

3. PRINCIPLES OF UNSTEADY FLOW

- Sewer flow is non-uniform and unsteady, and may be represented by the St. Venant equations for continuity and momentum (dynamic wave equation).*
- The method of solution of the equations should be consistent with the limits of accuracy of urban drainage studies.

4. UNSTEADY FLOW MODELLING IN SWMM TRANSPORT

- SWMM TRANSPORT contains a simplified version of the St. Venant equations.**
- The equations are solved by finite difference techniques and the accuracy of the model has been verified by measured flows.

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* Refer to "Storm Water Management Model Study", Volume II, Canada-Ontario Agreement Research Report No. 48, Section 1.

** Ibid, Volume I, Research Report No. 47, Section 4.2.2.1, and Volume II, Research Report No. 48, Section 1.

5. BACKWATER AND SURCHARGE LIMITATIONS

- SWMM routes hydrographs independently of downstream conditions, so potential backwater effects are not considered (except for flow control structures).*
- SWMM does not accurately simulate surcharge conditions. Excess inflows to a conduit are stored upstream until capacity becomes available.
- A hydraulic design option is included to revise pipes to accommodate free surface flows.

6. INFILTRATION AND SANITARY FLOWS

- For applications concerned with combined overflows, infiltration and sanitary flow will be important.
- Total infiltration is the sum of a dry weather component, which is relatively constant, and a wet weather component, which is a function of antecedent rainfall. When the sewer is below the groundwater table, infiltration is calculated as a function of the groundwater.**
- Average sewage quantity and quality characteristics are calculated as a function of land use. Correction factors are applied to allow for hourly variations.
- Routing of pollutants in SWMM TRANSPORT is based on the continuity of mass principle.

7. PHYSICAL SYSTEM REPRESENTATION

- The main drainage system is represented as a set of linked elements: conduits and non-conduits.
- The data input for conduits include geometric dimensions, invert slopes and Manning's roughness.
- Non-conduit elements are usually manholes, but may include lift stations, flow diversion structures and in-line storage.

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* Refer to "Storm Water Management Model Study", Volume I, Canada-Ontario Agreement Research Report No. 47, Section 4.2.2.1.

** Ibid, Section 6.2.

8. OUTPUT FROM SWMM TRANSPORT

- SWMM provides flow hydrographs at any point in the sewer system and volumes of surcharge (if any).
- If quality modelling is carried out, SWMM provides pollutographs for BOD, SS and coliforms.

9. THEORETICAL STUDIES WITH SWMM TRANSPORT

- Effects of routing distance, conduit lengths, surcharge, change in Manning's n.*

10. MODELS WHICH CONSIDER SURCHARGE

- The Dorsch HVM and WRE models simulate the sewer system as a network of interconnected segments. They have the capability to consider backwater effects, surcharge and looped sewer networks.**
- The WRE sewer hydraulics routine is currently being incorporated in SWMM.

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* Refer to "Storm Water Management Model", Volume I, Canada-Ontario Agreement Research Report No. 47, Section 4.3.2.

** Ibid, Sections 4.2.2.2 and 4.2.2.3, and Volume II, Research Report No. 48, Section 1.

LONG-TERM SIMULATION MODELS*

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GENERAL INTRODUCTION

As we have seen in the foregoing sections, single-event models like SWMM provide detailed information on only one event at a time and the initial conditions leading up to this event must be assumed. They provide no information on system behaviour or control effects over longer periods of time during which many events may occur. For example, a storage facility design for a 25-year event may in fact be overtopped by two closely-spaced events of more frequent occurrence.

For planning purposes continuous simulation models are needed since we are usually concerned with overall magnitudes and frequencies of storm flow events over long periods of time. Such models can be used to assess urban flow frequency relations, study the effectiveness of various control alternatives, and screen the record for critical events or groups of events which may be further modelled in detail.

Characteristics of most continuous models are high speed processing, use of less detail in defining the urban catchment and associated hydrologic properties, and in many cases no hydraulic flow routing.

Usually, several years of rainfall data can be analysed for the same cost as analysing a single storm event with a detailed model.

A number of continuous simulation models are available at the present time, which employ varying degrees of complexity in their computations. STORM is one of these. It was developed by the U.S. Army Corps of Engineers and has become quite popular both in the U.S. and Canada as a good "first-cut" or "planning" model. Some features of STORM which make it an attractive model are its relative simplicity, low cost to operate and ability to perform both quantity and quality simulation.

OVERVIEW OF "STORM"

STORM considers the watershed as a single catchment and performs no quantity or quality routing. Hourly runoff is computed from input rainfall, a selected runoff coefficient and a specified retention storage. Snowmelt may be computed in each hour using the familiar "degree-day" method. The lack of routing computations is not viewed as an omission since in many small urban catchments the routing effects are relatively small. Furthermore, overall volumes of runoff are usually more useful than flow rates for storage planning purposes.

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* Refer to "Storm Water Management Model Study", Volume 1, Canada-Ontario Agreement Research Report No. 47, Section 11.

Quality computations consist basically of computing the accumulation and subsequent washoff of dust and dirt on the urban subcatchment. The amount of pollutant washed off the land in each hour is computed as an exponential function of runoff rate, similar to the SWMM computation.

Various storage and treatment rates may be specified at the outlet of the area being modelled. STORM computes the hourly runoff, treatment rate, filling of storage and final overflow according to the specified sizes. Therefore, the long-term effects on reduction of overflows by various storage and treatment options may be evaluated.

Soil erosion from land areas may be computed using the "Universal Soil Loss" equation, an empirical relationship developed from agricultural research.

The newest version of STORM considers dry weather flow quantity and quality and so the model is directly applicable to combined sewers. In addition, unit hydrograph procedures have been incorporated into the runoff computation as an option.

INTERFACING DIFFERENT MODEL TYPES

Different types of models may be employed at various stages of a project, depending upon the information required. For example, in the initial stages of an overflow assessment study, general information on the magnitude and frequency of overflows over several years is usually required to place the problem in perspective. A continuous model could best furnish this information. Subsequent evaluation of specific control alternatives would call for more detailed information using a SWMM type model.

A complete urban runoff study might therefore consist of three separate stages: data preparation, planning, and design, each using a different type of model.

Data preparation involves manipulation of the large quantities of data especially meteorological, which are required by different models. Simple computer programs may be written for this purpose.

The planning stage involves a general assessment of runoff characteristics using a model such as STORM and/or a very simplified SWMM application for numerous events. The average number and volume of overflow events, average pollutant characteristics, and the timing and frequency of overflow events might be computed.

The design stage involves the application of a detailed SWMM model for a selected design event, and the detailed assessment of conduit capacities, surcharging, storage volumes and controls, treatment processes and effects on the receiving waters.

TESTING RUNOFF MODELS - QUANTITY SIMULATION

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1. WHY TESTING?

- There is no tradition or long-standing experience with models, therefore testing was necessary to provide confidence in the models.
- Testing against measurements was necessary to refine modelling techniques during development.
- There was a need to differentiate and compare the many models developed with regard to validity, applicability, advantages/disadvantages, quality of documentation, sensitivity, etc.
- Some models were calibrated on a few areas but not validated by split sampling.
- Some models required debugging.

2. PROCEDURES FOR COMPARISON WITH MEASUREMENTS [2, 3]

- Models are tested against measurements of rainfall and runoff.
- Several sets of measurements covering a variety of physical and hydrological conditions are required [1]
- Models are comprised of several distinct components (runoff, transport, etc.) which can be tested separately [1].
- Hydrologic phenomena are more difficult to define than hydraulics which can be more accurately represented mathematically.
- The RUNOFF component is best tested on relatively small watersheds in which hydraulic factors are minimal and hydrologic factors can be more accurately defined.
- The TRANSPORT submodel is best tested on larger watersheds where hydrologic variations are damped out and hydraulic effects are dominant.

3. TESTING SWMM RUNOFF AGAINST MEASUREMENTS [2, 3]

- Four test watersheds were used - Oakdale, Chicago, Calvin Park, Kingston and Northwood and Gray Haven in Baltimore - for which published data was available. Uncalibrated models were used.
- Peak flows were estimated within ±20% in most cases, the time to peak was very accurate and the real response of the system was well represented [1].
- Some of the discrepancy between computed and measured flows can be attributed to errors in the measurements.
- Results are consistently good for practical purposes and calibration does not significantly improve the results.

4. TESTING OF OTHER RUNOFF METHODS [2, 3]

- Other models compared with measurements in the Environment Canada study [3] were RRL, UCUR, QUURM and HVM (proprietary).
- Results indicate that all models can give good results, depending on the type of application and SWMM was found to be marginally better statistically.

5. TESTING THE RATIONAL METHOD [2]

- Rigorous testing of the Rational Method is not possible because of the block storms (uniform intensities) required and because only peak flows are generated.
- The Rational Method was tested against the measurements and it was found that errors ranged from +183% to -42%, indicating that this method is inconsistent and not always conservative.

6. TESTING THE SENSITIVITY OF SWMM RUNOFF [1]

- The sensitivity of the SWMM RUNOFF block computed peak flows and volumes was tested for variations in the hydrologic input parameters of 'infiltration, retention depth, ground slope, Manning's 'n', imperviousness, and width of overland' flow.

- Results in decreasing importance (sensitivity) were:

  1) % imperviousness (very sensitive),
  2) width of overland flow,
  3) infiltration rates,
  4) retention depths,
  5) roughness coefficients,
  6) ground slope.

7. TESTING SWMM AGAINST MEASUREMENTS [1]

- SWMM was tested on the Bannatyne district in Winnipeg, Brucewood, North York and West Toronto.
- The agreement for unsurcharged flows between recorded and computed hydrographs is quite good and the response of the watershed is well represented.
- The SWMM does not accurately simulate surcharged conditions. A more sophisticated routing model is required.
- Although they were not tested against measurements, a theoretical evaluation of the more simplistic routing methods of the RRL and UCUR models indicated that they can result in very large errors on large systems.

8. TESTING SWMM TRANSPORT SENSITIVITY [1]

- The sensitivity of the simulation of peak flow and volumes was tested for the length of conduit, the number of segments in a given length, pipe slope and Manning's 'n' and also the effect of surcharge.
- Pipe lengths should be limited to 4-5000 feet but the number of elements used in one uniform reach is quite flexible. As long as free flow is maintained, pipe slope variations are not significant. Surcharge can have a dramatic effect on peak flows since the hydrograph is truncated at the maximum conduit capacity.

9. COMPARISON OF MODELS FOR DESIGN CONDITIONS

- No measurements of design level storms are available for model testing. However, the comparisons that have been done indicate that those for the low intensity storms are generally not as good as for high intensities.

- Use of Rational Method can give very different results than the model, especially when the system is surcharged.
- The principal advantage of using the model is the possibility of considering all the available storm water management techniques now available. A great deal more information is provided for decision making and selecting between alternatives.
- The Rational Method should only be used for order of magnitude solutions and rough checks.

10. IS SWMM THE "BEST" RUNOFF MODEL?

- Advantages of SWMM were:
  - better documentation and refinement,
  - continuous updating and widespread application,
  - interfacing with total storm water management package,
  - non-proprietary and readily available,
  - comparison with measurements was as good or better than other models.
- SWMM has limitations, which are discussed elsewhere in these proceedings.
- Any model that has been thoroughly tested for similar conditions can be used in projects.

11. TESTING STORM

- STORM runoff computations were compared against both measured hydrographs and the SWMM results on the West Toronto and Bannatyne test areas [1].
- The comparisons indicated that the model gives a fair approximation of peak flows and a reasonably accurate prediction of runoff volumes.
- The number of combined sewer overflows measured on the West Toronto area was simulated within 10%.

12. CONCLUSIONS

- Testing shows that SWMM predicts peak flows, times to peak and total volumes accurately enough for planning applications and most design work [1].
- STORM should be used in screening studies for simulating the volume and number of combined sewer overflows, effects of storage and possible reduction of pollution from overflows for a long period of record.

REFERENCES

1. "Storm Water Management Model Study", Volume I, Canada-Ontario Agreement Research Report No. 47.

2. "Review of Canadian Design Practice and Comparison of Urban Hydrologic Models", James F. MacLaren Ltd., Canada-Ontario Agreement Research Report No. 26.

3. "Comparative Evaluation of Three Urban Runoff Models", J. Marsalek, T.M. Dick, P.E. Wisner and W.G. Clarke, Paper No. 75004, Water Resources Bulletin, Vol. 11, No. 2, April 1975.

TESTING SWMM ON CANADIAN WATERSHEDS - QUALITY SIMULATIONS

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1. TEST DATA

- Good quantity - quality data sets are difficult to obtain and are usually incomplete; for example, while hydrographs and pollutographs of some pollutants may be available, the required data on pollutant surface loading, dust and dirt composition and street sweeping frequencies, etc. may not be available.*

- Many factors affect the collection of good quality data including instrumentation problems, sampling location, type of samples collected (i.e., composite vs. discrete samples).

- The collection of quality samples must be synchronized with the timing of collection of rainfall and flow information. Ideally all three should be recorded on the same chart but this has rarely been done.*

2. CANADIAN STUDY AREAS

- Data suitable for modelling purposes were selected from a review of the various available data sources.*

- Measurements on the Brucewood catchment located in North York, Toronto were made by James F. MacLaren Limited during the period 1974-1975.

- Several pollutographs of BOD and SS were available from the Bannatyne combined sewer area in Winnipeg. The area is 542 acres of about equal parts of commercial and residential land use. Flows were measured using a weir and rainfall was recorded at a location outside of the catchment. An automatic sampler recorded quality samples for part of each storm event.*

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* "Storm Water Management Model Study", Volume I, Canada-Ontario Agreement Research Report No. 47, Section 3.

- Measurements were also available at the other locations. However in some cases only rainfall and flow measurements were available (e.g. Kingston, West Toronto); data from some sources were considered incomplete for detailed modelling purposes (e.g. East York, Montreal); data collected in Halifax were already under study by others. The measurements taken at the Malton Airport site were studied as part of an assessment of environmental problems.*

- Fisheries and Environment Canada has recently initiated data collection programs in Hamilton and Toronto on 176 and 338 acre watersheds, respectively. Measurements include precipitation, flow quantity and quality, as well as information pertaining to snow removal and municipal cleaning practices. Both these data sources are potentially excellent sources of runoff data specifically oriented towards runoff modelling.*

3. MEASUREMENT TECHNIQUES

- Both quantity and quality measurements are required, with good time synchronization. A large number of events should be monitored to ensure good data.

- Automated instrumentation is necessary because many storm events occur in off-hours. From experience many factors can cause an event to be missed so it is important that the instrumentation is set up to monitor all events of interest.

- Some successful monitoring installations required a year or more to de-bug procedures and instrumentation and work out the mechanics of installing and maintaining equipment.

- Flow measurements require a control device (weir, flume, etc.) for accuracy. The location and installation of weirs etc. may be quite difficult. Expedience in location often conflicts with the need for good measurements for both quantity and quality. Various types of stage measurement devices are available, many with the option of chart recorders or telemetering capability; different types are "bubblers", "dippers" or float operated.

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* Ibid.

- Automatic samplers should be activated by stage recorder. Different types of sampling can be done depending on the requirements:
    - discrete,
    - simple composite,
    - flow proportional,
    - sequential composite.
- Rain gauges are of two types - tipping bucket or volumetric (weighing) type. Rain gauges can also telemeter signals or use in-situe recorders. This part of the instrumentation usually provides the fewest problems although care must be taken in its placement.

4. PREVIOUS QUANTITY - QUALITY MODELLING STUDIES

- Previous quality simulations were carried out mainly by the model builders. A typical test example of Atlanta is given in the literature review, Volume II*.
- The studies conducted in the U.S. have tended to demonstrate that the quality simulations are reasonable.
- Data suitable for modelling purposes currently available in the U.S. has deficiencies similar to those previously given for Canadian data. A data bank of urban storm water runoff quantity and quality data is currently being set up and maintained by the University of Florida.

5. MODEL TESTS USING CANADIAN DATA

A. Brucewood Catchment

- The Brucewood separate storm sewer system located in North York, Toronto drains a 48 acre residential area of about 47% imperviousness.
- Six storms were selected for comparison of measured data with quality simulations using SWMM. The results of these simulations are given

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* Canada-Ontario Agreement Research Report No. 48

in Section 5 of Volume I of the storm water management model study (Canada-Ontario Agreement Research Report No. 47). Of the storms selected, three had maximum rainfall intensities less than 0.60 inches per hour and only one had a peak intensity greater than 1.0 inch per hour.

- SWMM default values for various parameters were used in the simulation unless otherwise indicated. In some cases the measured pollutant composition of dust and dirt was used, as determined by measurements taken prior to the event.
- The results of the simulations indicated that for low pollutant surface loadings, the option ISS=1 (empirical equation) for suspended solids calculations gives better results than ISS=0.
- Improvement in simulations can be made by supplying measured pollutant dust and dirt composition and accumulation rates if available.
- Results of the simulations indicated that the pollutographs computed using SWMM are the same order of magnitude as the measured values.
- Some calibration runs using the Brucewood data were also made using the generalized quality model which is described in Chapter 10 of Volume I. Typical results indicated that fitting simulated and measured pollutographs is possible by modifying parameter values and using measured accumulation pollutant composition.

B. Bannatyne Catchment

- The Bannatyne combined sewer system located in Winnipeg drains a 542 acre residential and commercial area.
- Five storm events were considered suitable for simulation. BOD and SS were the only measured quality parameters.
- Preliminary simulations indicated that accounting for the dry weather flow contribution to the pollutograph is very important. Average DWF values of 5.6 cfs with SS and BOD concentrations of 558 mg/l and 391 mg/l, respectively, were used.
- SWMM default values were used in the simulations unless otherwise noted.

- Simulations indicated that, due to the flat transport pipes, substantial deposition of solids simulated in the pipe system and washout of these solids resulted in high SS concentrations. Field observations noted by engineering personnel in the City of Winnipeg have confirmed the occurrence of this.

- Comparison of total measured and simulated mass of pollutants washed off had a fair agreement; pollutographs are compared on figures in Section 5 of Volume I.

6. SENSITIVITY AS A TESTING METHOD

- As indicated in Figure 35 on p. 101, Volume I, the SWMM storm water quality simulations are dependent upon several parameters. The relative sensitivity to the quality simulations of the following parameters has been examined:

  - the exponent 6 in the exponential washoff equation,
  - the 2 options for computation of suspended solids,
  - the number of dry days and the street cleaning frequency,
  - the catch basin BOD,
  - pipe slopes in the TRANSPORT quality computation,
  - the specific gravity of solids in TRANSPORT deposition and scour calculations.

- Reference to Figure 36, p. 106, Volume I, indicates the variations possible in b under different washoff assumptions. The value of 4.6 used in the model appears to be a "representative" average. While some calibration can be achieved by modifying b, the assessment of initial pollutant loads is far more sensitive.

- The difference in results obtained by using the two washoff equations for SS calibrations was found to vary according to differences in initial pollution load. For low initial loads the ISS=1 option gives higher concentrations, and for high initial loads, the exponential equation gives more washoff.

- The initial pollutant loading is the most sensitive parameter. The number of dry days, street cleaning practices and dust and dirt accumulation rates and composition all affect this calculation.

- Variations in catch basin BOD concentration are important only for low intensity storms.
- When transport pipe scopes are small, the deposition of solids in the sewers becomes very important. Variation in the specific gravity of solid particles is not considered to be useful for calibration purposes unless local measurements are available. Accounting for BOD delay in transport may be important only in very large systems.
- The SWMM quality model responds logically to variations in input parameters.
- The most sensitive parameters are initial pollutant loads.

7. CONCLUSIONS

- The state-of-the-art of storm water quality modelling has not advanced as far as that of quantity modelling. However, it is possible to obtain simulated pollutographs of the same nature as measured pollutographs for both separate and combined discharges.
- Neither of the options provided in SWMM for SS computations is adequate over a wide range of antecedent conditions. When the initial pollutant loading is very high the exponential equation (ISS=0) will simulate higher concentrations than the empirical equation. Conversely, when the initial pollutant loading is fairly low, the empirical equation will simulate higher concentrations.
- More research is required to find a surface washoff equation applicable to a wider range of accumulation values.
- The SWMM quality model is rather difficult to calibrate, partly because certain variables are fixed in the program. When the primary concern is surface runoff a simplified approach may be justified and this is considered in a generalized quality model (Chapter 10, Volume I).
- Initial conditions have been shown to control the quality computation; consequently, the initial conditions for one event quality modelling should be defined in conjunction with continuous long term simulation models.

- Changes in parameter values are reflected logically in simulation results. The quality model in its present stage can be regarded as a very useful tool for the comparison of storm water management alternatives.

LUMPED SIMULATION*

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1. GENERAL INTRODUCTION

- Detailed simulations are relatively expensive, and so is the collection and setup of the necessary data.
- Depending upon the objective of the simulation, it is possible to obtain reasonably accurate outlet hydrographs with greatly reduced simulation detail, in terms of the numbers of subcatchments and pipes modelled.
- Until recently, little guidance was available on the level of detail necessary in any specific modelling instance.
- Simplified or "lumped" simulation is a planning technique, and is not meant to replace detailed simulation.
- If only the overall catchment response is required, it may be advantageous to adopt a "lumped" approach. If it is desired to study the variation in response within the catchment, or to examine flow conditions in trunk conduits, a detailed approach is called for.
- The "lumped" approach does not take into account the spatial variation of the parameters which determine runoff.

2. BASIC CONCEPTS

- Overland flow is determined on each subcatchment as the uniform flow velocity times the excess water depth and the width of the subcatchment.
- The parameters which determine the depth and velocity of overland flow, such as slopes, roughness, infiltration, etc., can be averaged over larger areas and still maintain average velocities.
- The "width" parameter, however, is a measure of the ease with which surface runoff may enter the sewer system, and is a function of the drainage conduit density and the spacing of inlets.

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[*] Refer to "Storm Water Management Model Study", Volume I, Canada-Ontario Agreement Research Report No. 47, Section 9.

- Therefore, theoretically, whether an area is broken into a number of small subcatchments or a single large one, the total overland flow "width" should be similar.
- By reducing the width less opportunity for overland flow exists, and more excess rain must be stored on the surface of the subcatchment, thus creating "artificial" storage in the system.
- Artificial storage created in this way may be used to compensate for conduit storage that is neglected as fewer and fewer conduits are modelled.
- Conduit routing effects, as computed in the TRANSPORT block, are determined primarily by the geometric properties of the conduits.
- Combining several conduits is often necessary, and is best achieved by computing average conduit properties.
- In "lumped" simulations involving only a few, or a single subcatchment, most of the sewer system must be ignored.

3. LUMPING PROCEDURES

- The basic problem in conducting a simplified simulation is to account for neglected conduit storage. Neglected storage results in higher peak flows.
- Two approaches may be used to conduct a lumped, single catchment simulation.
- The overland flow width of the single catchment may be measured from the detailed drainage system, resulting in a higher overland flow peak. An equivalent conduit may be used to attenuate the overland hydrograph, and determine the outlet hydrograph.
- Alternatively, a reduced overland flow width may be used, and no conduit modelled at all. The reduced "width" will provide artifical storage which will attenuate the overland flow hydrograph directly. A reasonable estimate of this reduced "width" may be made by measuring the longest diagonal of the lumped catchment being modelled.

- These procedures were tested on several catchments, and a reasonably close agreement was achieved between "lumped" and detailed simulations.
- Surface runoff quality parameters also respond well to lumping, with only very small differences between lumped and detailed simulations.
- "Lumped" simulations may be conducted on a given catchment by using average values of runoff parameters for the entire catchment. An initial estimate of the lumped catchment "width" can be taken as twice the length of main sewer conduit in the catchment, when no TRANSPORT routing is used.
- Calibration of the "lumped" model is effected in the same fashion as the detailed model. The estimated "lumped" width must also be considered to be a calibration parameter.

MODELLING URBAN SNOWMELT RUNOFF QUANTITY AND QUALITY*

Harold S. Belore
James F. MacLaren Limited

1. IMPORTANCE OF SNOWMELT QUANTITY

- The relative magnitudes of peak summer flows and peak spring flows from intermediate sized rural basins can vary with return frequency as indicated on Figure 1. Depending on size, hydrologic/hydraulic response and geographic location, the spring flow may be important for design purposes.
- An assessment of spring flow has proven important in cities such as Winnipeg and Ottawa.
- Due to the larger runoff volumes involved (see Figure 2) an assessment of spring runoff conditions becomes even more important where storage ponds are considered either as flood control and/or storm water pollution control measures.

2. IMPORTANCE OF SNOWMELT QUALITY

- Most previous studies have been directed towards measuring the amount of various pollutants found in snow and snowmelt waters. Tables 1 and 2 summarize the range of various pollutant concentrations found in snow at different locations in Ontario.
- A major environmental concern continues to be the quality of snow being disposed of and the melt water effects at the disposal site and in the receiving waters.
- The various studies to date have indicated that chlorides and lead are the most widespread and serious snow contaminants, although a myriad of other pollutants can also be present in smaller concentrations.

3. SNOWMELT QUANTITY MODEL

- Considering snowmelt as essentially a heat transfer process, the following simplified general equation can be used to estimate the

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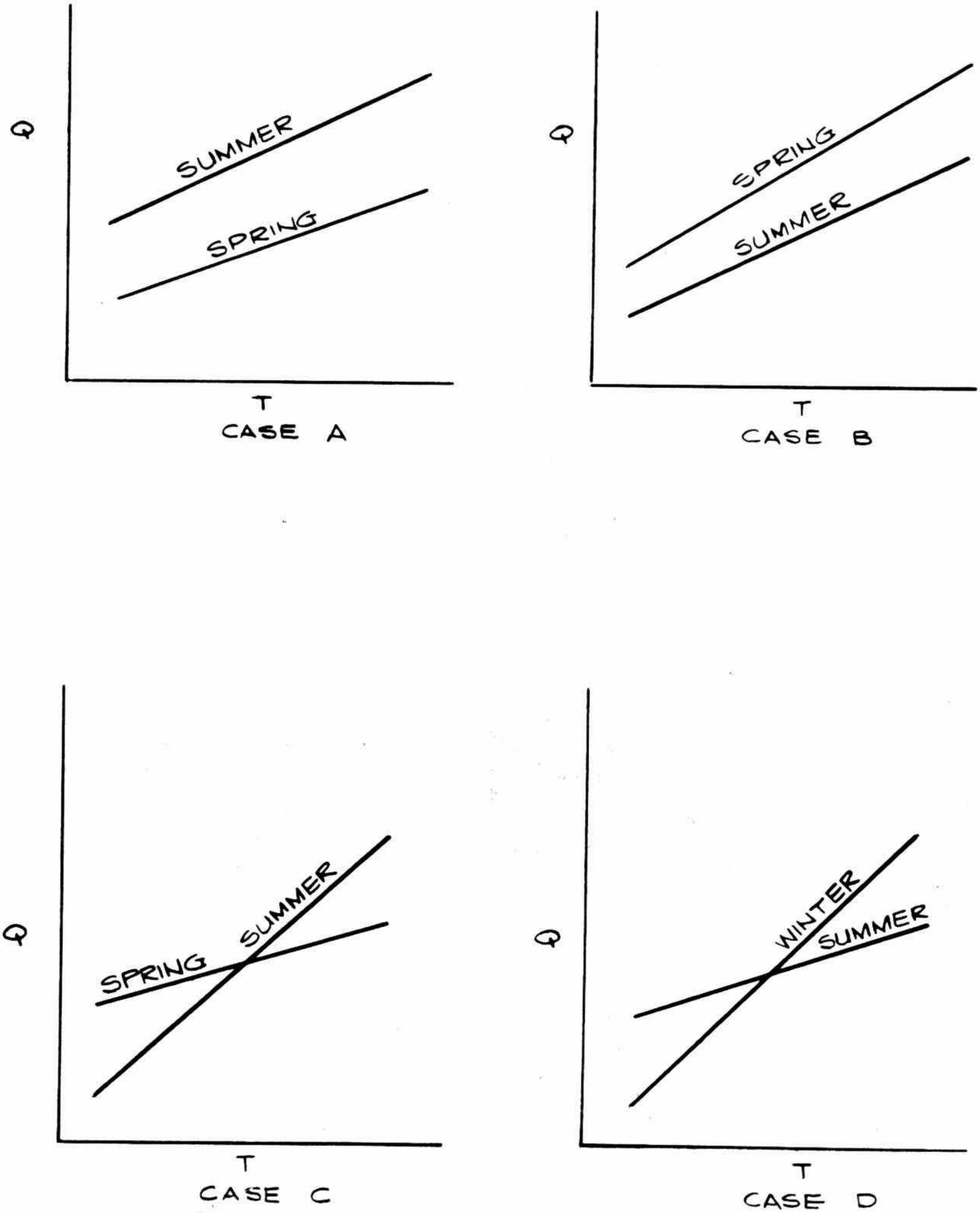
* Refer to "Storm Water Management Model Study", Volume I, Section 8, Canada-Ontario Agreement Research Report No. 47.

POSSIBLE ORIENTATION OF SUMMER AND SPRING FREQUENCY CURVES *



Q = PEAK FLOW
T = RETURN PERIOD

* STODDARD, R. B. L. AND W. E. WATT
"FLOOD FREQUENCY PREDICTION
FOR INTERMEDIATE DRAINAGE BASINS
IN SOUTHERN ONTARIO"
DEPARTMENT OF CIVIL ENGINEERING
QUEENS UNIVERSITY
CE RESEARCH REPORT NO 66
JULY 1970

FIG. 1

GENERALIZED COMPARISON OF SPRING AND SUMMER DESIGN HYDROGRAPHS

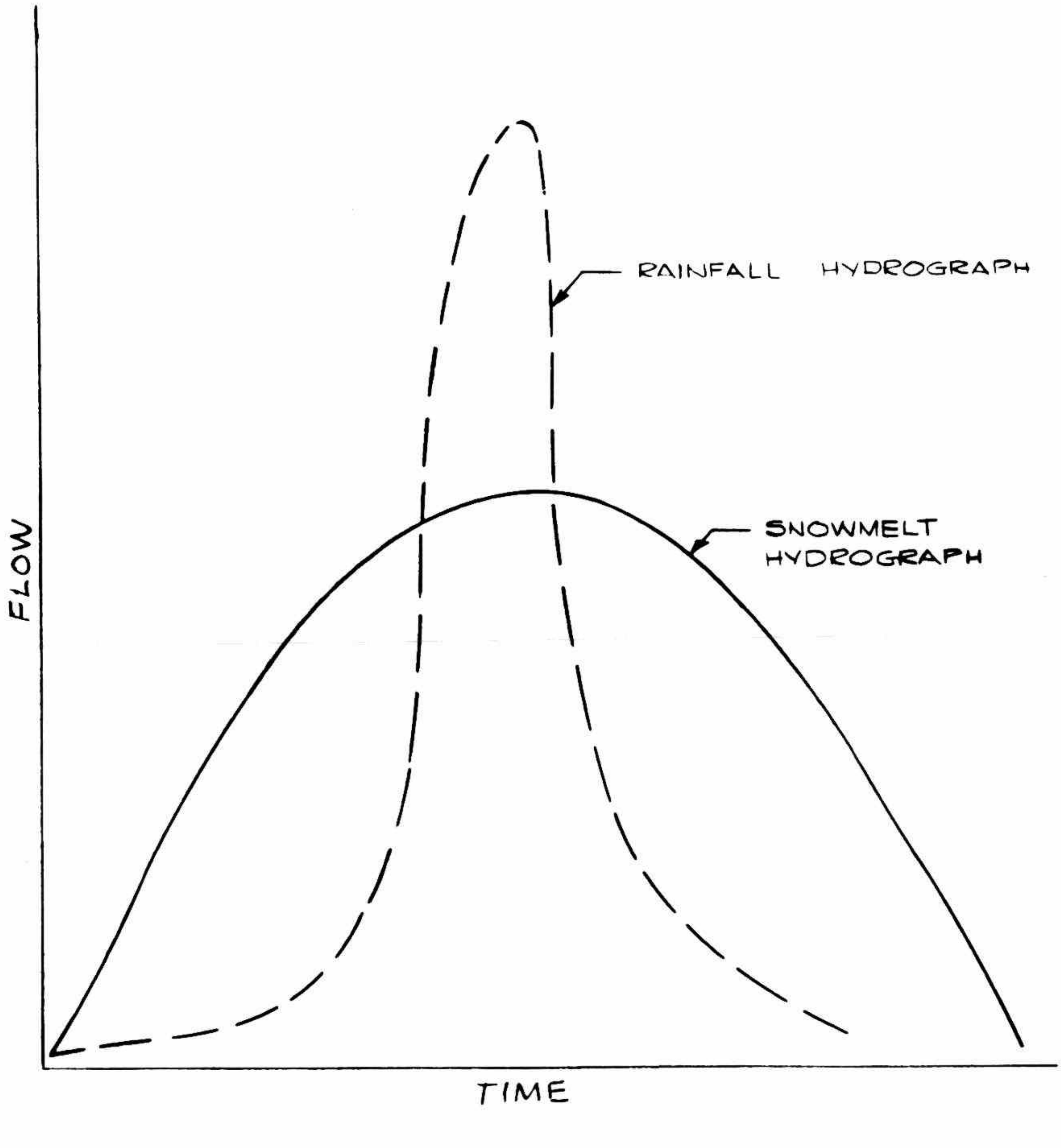


FIG 2

TABLE 1. SODIUM AND CHLORIDE CONCENTRATIONS[*]

	Sodium (mg/kg)				Chloride (mg/kg)				
	Arterial	Second.	Resid.	Dump	Arterial	Second.	Resid.	Dump	Park
Toronto					13325	9310		11840	14
Ottawa	2254	981	445		3321	1607	990	3965	
Windsor	3130	3557	489		4852	5357	856		
Barrie	300	61	81.5		600	94	126		
Timmins	942	234	118		1476	384	191		
Belleville	5115	1579	200		8114	2674	339		

TABLE 2. REPORTED SNOW AND SNOWMELT WATER POLLUTANT CONCENTRATIONS

Pollutant	Observed Range (mg/l)
Chloride	7-15580
Lead	0.02-113
BOD$_5$	1.4-84
Suspended Solids	1-4020
Organic Nitrogen	0.09-4.3
Nitrate-N	0.01-1.5
Ammonia-N	0.1-0.3
Total Phosphate	0.036-3.6
Sodium	3.6-9480
Phenol	.002-.125

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[*] Summarized from literature review, Volume II, "Storm Water Management Model Study", Canada-Ontario Agreement Research Report No. 48.

amount of melt:

$$M = M_n + M_e + M_h + M_p$$

where: M = total melt (inches or cm),

M_n = melt due to net radiative heat transfer,

M_e = melt due to latent heat transfer,

M_h = melt due to sensible heat transfer,

M_p = melt due to heat transfer by rain.

- The numerical equations chosen are summarized on the generalized algorithm, Figure 64, p. 174, Volume I. Anderson's snowmelt equation is used for rainy periods and the degree-day equation is used to model the total volume of melt during non-rain periods.

- Modifications to the SWMM RUNOFF block have been made which allow the user to specify additional snow-covered pervious and impervious catchments.

- The distribution and amount of snow cover is assumed to be known prior to the simulation of the event. The user must specify a temperature sequence for the event.

4. SNOWMELT QUALITY MODEL

- The literature review indicated that there were no suitable snowmelt quality models available for integration with SWMM. In the absence of specific information concerning the modelling of snowmelt quality, the general exponential washoff equation currently used in SWMM was adopted.

- In addition to the pollutants normally modelled, lead and chlorides were added. The initial amount of lead is computed in the program by specifying an accumulation rate in terms of pounds per 100 ft of gutter per day. It is assumed that the initial amount of chlorides applied for various catchments can be estimated from municipal salting records or estimated salting rates and input to the model. (See Table 3, for example).

TABLE 3. SALTING RATES IN ONTARIO*

Population Density (per sq. mile)	Rates of Salt Application (lb per app. per lane-mile)
Less than 1000	75 - 800
From 1000 to 5000	350 - 1800
More than 5000	400 - 1200

* Summarized from M.O.E. "Municipal Snow Quality Study" (1972) and "Results of Municipal Snow Quality Study" (1973).

5. TESTING SNOWMELT QUANTITY AND QUALITY SIMULATIONS

- Very little data suitable for model testing of snowmelt quantity and quality relationship is available for urban watersheds. At the present time, a data collection effort is being sponsored by Fisheries and Environment Canada to provide quantity and quality data for rain on snow events.
- A few low-intensity runoff events were monitored during the winter of 1974-1975 from the Brucewood catchment located in North York, Toronto. Simulation results were compared to measured values for the event of March 12, 1975. Peak flows were only about 1 cfs but the measured and computed values were of the same general nature.
- Figure 66, p. 183, Volume I, shows the hypothetical results of a higher intensity storm on a deeper snowpack (2.5 inches water equivalent). The simulation results indicate that the model is working as expected and also demonstrate that even for higher intensity rainstorms the snowmelt component can account for a significant portion of the hydrograph.
- Figure 67, p. 185, Volume I, shows a simulation result compared to hydrograph measured from a portion of Malton Airport. The results indicate a reasonable simulation.

6. CONCLUSIONS

- Snowmelt quantity and quality models have been developed and integrated with the SWMM RUNOFF block. Preliminary testing indicates that the models are working as expected.
- More measurements of high intensity snowmelt and rainfall plus snowmelt runoff events are required in order to completely verify and test the models.

THE SWMM STORAGE/TREATMENT SUBMODEL - RELATIONSHIPS FOR QUALITY SIMULATION*

Philip Dick
Proctor & Redfern Limited

1. INTRODUCTION

The objectives of the Storage/Treatment block are to provide the capability of modelling a considerable number of alternative sewage treatment processes and to restrict certain process combinations which are deemed inadmissable; to simulate improvements in overflow quality produced by each component of the selected combination of treatments; and to summarize data required for the estimation of treatment costs for the programmed installation.

2. DESCRIPTION OF THE STORAGE/TREATMENT BLOCK

A. Broad Description of Storage

- Two different types of basins may be modelled, namely irregular, which normally corresponds to types associated with damming up a valley, or geometric, which normally corresponds to man-made basins of concrete or other suitable materials.
- These two types of basins may have inlet/outlet controls in the form of weirs, pumps, orifices, or any other number of such controls.
- With this selection of basin types and controls, the storage system may be on or in-line with the stream of flow, or placed to the side of the stream of flow and filled and unfilled at appropriate intervals. This later type is considered off-line storage.
- To provide even greater flexibility so as to model the in-situ conditions as realistically as possible, the flow regimes of plug or completely mixed may be selected.

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* Refer to "Storm Water Management Model Study", Volume I, Section 7, and Volume II, Section 7, Canada-Ontario Agreement Research Reports No. 47 and 48.

B. Broad Description of Treatment

- The basic treatment concept that is iterated in all but a few treatment options is solids removal. These treatment options are bar racks, dissolved air flotation, fine screens, etc. with the effective efficiency removal of "x" % respectively. The selection of treatment options are stepped from the most "inefficient and crude" treatment to the most sophisticated (bar rack versus microstrainers). Each treatment option has its benefits and disadvantages.

  Each of the above units provides some degree of BOD reduction due to the removal of the solids. Some solids contain organics that may, in one form or another, be utilized by certain organisms resulting in O_2 reduction in the receiving water body.

- BOD removal is primarily accomplished in only one treatment option, namely biological treatment. Removal of soluble BOD is efficiently accomplished by microorganisms that must be removed by settling operations. Application is limited due to the requirement that living organisms be returned to the aeration basin to continue the high level of substrate transformation. Cyclic operation as required or dictated by storm wastewaters is not conducive to this option.

- The final "treatment" the waste stream receives is chlorination for the destruction of pathogenic organisms. Two options are available for this, namely, normal chlorination or high rate chlorination. Note that no BOD reduction occurs in this process.

C. Broad Description of Cost

- Capital cost for storm water treatment facilities involved adjusting STP cost curves developed in the U.S., and utilizing cost figures, estimates of equipment, and installation costs to develop the new Canadian cost curves.

- Maintenance and operating cost figures were not changed due to the lack of any significant information on this area. It must be noted that pilot systems do not give a true picture of expected costs. These are normally installed only on a temporary basis with government personnel. In the future, these facilities will be permanent and installed by a contractor. Costs will rise.

3. COMPUTER ASPECTS OF STORAGE/TREATMENT BLOCK

A. The major subroutines that perform the base calculations are TRTDAT, STORAG, TREAT, TRCOST, STRDAT, STRAGE. These subroutines perform the following functions: STORAG - coordinates program for all water and pollutant movements through the storage and treatment facilities modelled, TRTDAT - etc.

B. The minor subroutines support the major routines and are SPRINT, TRECHECK, BYPASS, TRLINK, KILLSEDIM, HIGHRF, STROUTE, PLUGS, INTERP. These subroutines perform the following functions: TRCHECK - called by subroutine TRTDAT to check the specified treatment options for inadmissible or uneconomical combinations, SPRINT - etc.

C. There are 24 data cards that must be (maximum) coded, in conjunction with the rest of the model, in order for the model to function properly. Rather than list all here at this time, the cards that have significant impact on the output from the model are: Execution Control Data, Treatment Control Data, Print Control Cards, Flow Design, Cost Data, Cost Index. The limitations for each set is as follows: ... The remaining cards are easily coded by the directions in the user's manual (Volume III, Research Report No. 62).

4. DISCUSSION ON SOME APPLICATIONS

A. The need for this entire model came to be because of the growth of our country and the subsequent urbanization of certain areas with subsequent pollution to our watercourses. Only typical characteristics and ranges of pollution discharged to our receiving water bodies are known.

B. Early solutions to storm water problems were, "no solution", just discharge. Then it became fashionable to combine the two waste streams (storm and sanitary) and treat what was possible in a domestic STP, with overflow to the receiving water body.

Now it is popular to provide separate sewer systems and treat only one. The future now might indicate resorting to combined sewer systems again and treatment of overflow. The Chicago Project, probably the most daring for its time, combines storage of combined sewers systems and treatment by STP.

C. The importance of storage cannot be over-emphasized. Not only does it provide a treatment by solids removal, but attenuates flows to reduce size and costs of treatment facilities. Uses have not been limited to upstream and downstream storage. Land practices have also reduced flows, for example, porous parking lots.

D. Model limitations occur in the treatment equations and the storage routine. The treatment options are based on steady state conditions (by their averaging) with little significant data. The storage routine should be, and is being, completely rewritten to reflect more practical application approach. The future of modelling is that it will play a significant part in the selection of the most economical solutions to storm wastewater treatment. As more new facilities are built, and the more significant testing, data, and data analysis occurs, the more reliable the models become. Presently, these models must be used with the best engineering judgement available, as an aid, not as the sole decision tool. Note, only BOD, SS and coliforms are the indicating parameters for measurement of pollution. How good is the treatment/storage routine? Before this can be answered, Andy Roake will discuss the receiving water body model. Only after this is evaluated can we make a decision.

RECEIVING WATER MODELLING - THE RECEIV SUBMODEL*

Andy F. Roake
James F. MacLaren Limited

1. BACKGROUND

- One of the principal reasons for modelling quality of urban storm flows is to quantify the amounts of pollutants reaching the receiving water.
- The flow rate/size and temperature of the receiving body control its capacity to assimilate a certain pollutant. The desired range of uses for the water determines how much of the assimilative capacity can be used. These factors decide the degree of treatment of various pollutant sources required.
- Some pollutants break down to harmless chemicals or become biologically stabilized in time. These are called non-conservative; an example is BOD. Conservative pollutants remain in a potentially harmful form for long periods of time. Heavy metals are an example.
- We are normally interested in studying the effects of non-conservative pollutants over a short period, i.e. until they break down to a harmless substance. We may also be interested, if studying a flowing system, in identifying the distance from the discharge where the maximum effect occurs (an example is the point of minimum dissolved oxygen in a river receiving a BOD discharge).
- When studying substances that don't break down rapidly, we have to consider the effect of their accumulation over a long period. This means we are interested in, say, annual loads rather than isolated peak concentrations.
- Also we must consider where these conservative pollutants end up. If our discharge is to a river, do they settle on the bottom, or

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* Refer to "Storm Water Management Model Study", Volume I, Section 6.2, Canada-Ontario Agreement Research Report No. 47.

are they carried to a lake downstream? What is the ultimate receiving water body and what effect will long term accumulations have there?

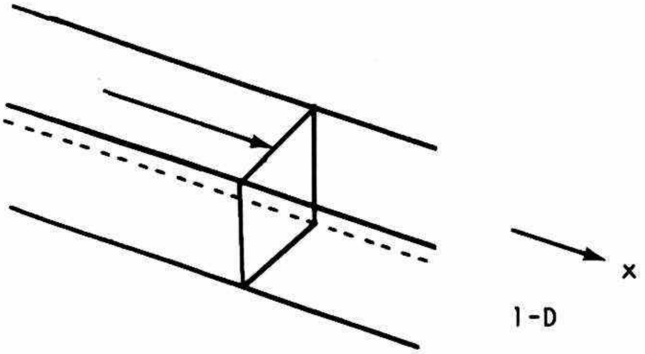
Receiving Water	BOD	Suspended Solids	Heavy Metals	Nutrients (N and P)
River	3	3	2	1
Lake	2	3	3	2
Estuary	1	2	2	1
Sea	-	-	3	3

(3) Very important
(2) Moderately important
(1) Minor importance
(-) Not usually significant

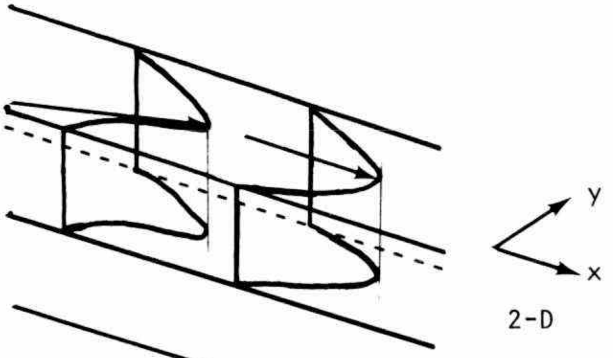
2. MODELLING

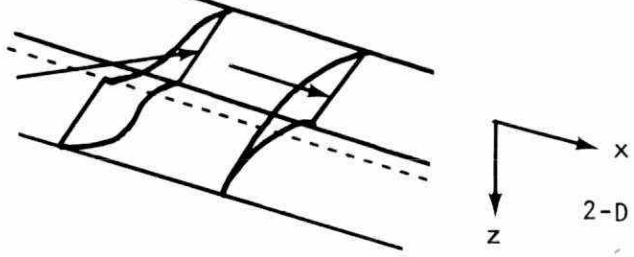
- The type of receiving water body under consideration often determines the type of model required. It should be noted that the transport of pollutant by the bulk movement of the flow is usually the most important transport mechanism. Consequently, as in the sewer system, an accurate determination of flow patterns is necessary for an accurate picture of pollutant transport.

- The available models are normally classified according to the number of dimensions in which the flow velocity may change:



Water Body





3. SWMM RECEIVING MODEL

- The SWMM model is of the node and channel type. Nodes are assigned characteristics of volume, surface area, depth and water elevation. These are all averaged over the nodal area. Nodes are connected by channels. Both 1-D series of channels and pseudo 2-D networks are allowed.
- The equations of motion (in 1-D) and continuity are solved (explicitly) at each time step. Once the flow patterns have been established, the conservation of mass is solved to determine pollutant concentrations at nodes.
- Because of the node and link representation, the model is very flexible and requires relatively small amounts of input data. Several downstream and open water boundary conditions are possible-

  downstream head relationship (dam),
  tidal boundary,
  specified overflow,
  or some combinations of these.

- Since the model is 1-D, it is expected that it will give most accurate simulations when the 1-D assumption is valid. For a large number of river and estuary configurations, SWMM will be sufficiently accurate for planning purposes.
- The model should not be used in situations where the main pollutant transport mechanism is not the bulk motion of the flow. In particular, the model is not applicable to diffusion controlled reactions, e.g. finger fill canals.
- Since there is little natural inflow, diffusion is the main transport mechanism.

Handout

1. Orlob, G.T., "Mathematical Modeling of Estuarial Systems", a paper presented at the International Symposium on Mathematical Modeling Techniques in Water Resources Systems, 1972.

DATA ANALYSIS MODEL*

Les Pataky
Proctor & Redfern Limited

1. DATA REQUIREMENTS OF THE URBAN RUNOFF MODELS SWMM AND STORM

- Both programs attempt to model the real physical processes involved with the runoff phenomena and, require extensive data input and preparation.
- Calibration of both models is important, requiring records of both the outflow hydrograph (and pollutograph if quality is to be modelled) and the input rainfall records for particular storm events.
- Long-term simulation will require the preparation of many years of rainfall data.
- Often several gauging stations may be close to a given study area and the records from each may be used to obtain a weighted rainfall, thereby accounting for the spatial variation of precipitation.

2. AES DATA BANK

- The Atmospheric Environment Service (AES) of Fisheries and Environment Canada holds virtually all climatological data collected in Canada, which have been machine-processed since about 1950.
- Data is available from them in the form of punched cards or magnetic tape.
- Twenty-one different data formats or "card types" are presently used by the AES to summarize the measured daily data.
- Card types 3 and 4 contain the hourly precipitation data and temperature data required for urban runoff modelling.
- Short interval precipitation data has not been digitized into the bank but must be obtained from photocopies of the original tipping bucket records.

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* Refer to "Storm Water Management Model Study", Volume I, Section 12, Canada-Ontario Agreement Research Report No. 47.

- Certain quality control procedures are used by the AES to check the data for accuracy, completeness and random errors.

3. DATA ANALYSIS MODEL - INTRODUCTION

- This model was developed to reduce the time, cost and tediousness of transforming the data available from the AES to a form suitable for STORM and SWMM.
- Features of the model include data screening for faulty data, line printer plot of temperature, records mass analysis of precipitation data, the facility to combine the records of several gauges, double mass analysis, and storm summaries for individual or combined rainfall records.
- The model is made up of three separate programs which may be used individually or in combination to perform the desired operations.
- Input or output may take the form of cards, magnetic tape or disc storage.

4. PROGRAM I: DATA BANK PROCESSING (DBP)

- The function of this program is to screen the type 3 and type 4 AES data and to produce a data base for long-term simulation by STORM.
- Beyond the AES data only minimal user-defined control cards are required to operate the program.
- Type 4 precipitation data is used to complete the precipitation data in cases where type 3 data are faulty or unavailable.
- Interruption of program due to title cards and faulty data within the AES types 3 and 4 data has been prevented by a data checking routine. This routine reads the AES data in alpha mode and converts the data to the appropriate numeric form as well as discerning overpunches and invalid data.
- A plot feature is available which permits a quick visual inspection of the processed temperature file.

5. PROGRAM II: RAINFALL ANALYSIS PROGRAM (RAP)

- The function of the Rainfall Analysis Program is to combine the rainfall records of two or more gauging stations into a single record based on user-supplied weighting factors.

- These weighting factors may be calculated by any method. (i.e. Theissen Polygon, Arithmetic Weighting, Distance Weighting).
- A mass curve for precipitation is plotted for each gauging station after processing.
- Double mass analysis may be used to check the consistency of a gauge record by comparing its accumulated precipitation record with the concurrent accumulated average values for several surrounding stations. This feature of the program also takes the form of a line printer plot.
- A storm summary of the combined precipitation record is also available based on a user-supplied storm definition.

6. PROGRAM III: SHORT INTERVAL RAIN DATA PROCESSING

- This program has been developed to accept digitized rainfall records in any units of rainfall, amount, and time, and to compute the weighted average of several gauges, as well as punching the resulting hyetograph in any specified time interval.
- The weighting procedure for gauging stations is the same as in RAP.

SELECTION OF MODELS FOR URBAN DRAINAGE PROBLEMS: TECHNICAL ASPECTS AND NON-TECHNICAL CONSTRAINTS

Paul E. Wisner, Adel F. Ashamalla, and Patrick A. Ahern
James F. Maclaren Limited

INTRODUCTION

Several recent studies have indicated the existing gap between available modelling capability in urban drainage and the current status of the application of models in practical problems [1,2]. In the past, most drainage projects have been approached as straightforward conduit design exercises, i.e. sizing of storm sewers or open channels to convey design flows from the particular study area. The Rational Method, attributed to Kuichling in 1889, is presently the most used method for calculation of the design flows. The limitations of this method, which can be regarded as a very simplistic model, have long been recognized and are explained in recent publications [2,3].

Within the last fifteen years, considerable effort has been directed towards improved representation of urban rainfall-runoff processes through development of hydraulic models for overland flow and conduit flow routing. A recent study by Brandstetter describes and compares 25 such models having varying degrees of sophistication, including capability for simulation of water quality [4]. Some of these models are presented in Table 1, and many of them have been shown to provide a better estimation of storm water flows than the Rational Method [3].

Although some models have also been used widely to assist in evaluation of storm water management alternatives, not all practising engineers are convinced of the advantages of the new simulation methods now available. Implementation of urban drainage modelling may require a significant effort in training municipal staff and in analysis of drainage alternatives. Experience has shown that the argument of a somewhat improved flow simulation does not provide a sufficient advantage to justify the costs of model implementation. On the other hand, large scale application of computer models by municipalities in other problem areas, such as analysis of water distribution networks, indicates that the engineering profession will accept new modelling technologies if the advantages are clearly demonstrated.

TABLE 1. MODEL CHARACTERISTICS [16]

	CATCHMENT HYDROLOGY							SEWER HYDRAULICS							
	MULTIPLE CATCHMENT INFLOWS	DRY-WEATHER FLOW	SEVERAL RAINGAGES	SNOWMELT	RUNOFF FROM IMPERVIOUS AREAS	RUNOFF FROM PERVIOUS AREAS	WATER BALANCE BETWEEN STORMS	OPEN CHANNEL NETWORK	UPSTREAM & DOWNSTREAMFLOW CONTROL	SURCHARGING AND PRESSURE FLOW	DIVERSION STRUCTURES	PUMPING STATIONS	STORAGE	COMPUTES STAGE	COMPUTES VELOCITIES
BATTELLE NORTHWEST	●	●	●		●	●		●			●		●	●	●
BRITISH ROAD RESEARCH LABORATORY	●	●	●		●			●							
CHICAGO FLOW SIMULATION	●	●	●	●	●	●	●	●					●	●	
CHICAGO HYDROGRAPH METHOD	●	●	●		●	●	●	●							
COLORADO STATE UNIVERSITY	●	●			●			●	●					●	●
CORPS OF ENGINEERS				●	●	●	●				●		●		
DORSCH CONSULT	●	●	●		●	●		●	●		●		●	●	●
ENVIRONMENTAL PROTECTION AGENCY	●	●	●		●	●		●	●		●	●	●	●	●
HYDROCOMP	●	●	●	●	●	●	●	●	●	●	●		●	●	●
MASSACHUSETTS INSTITUTE OF TECHNOLOGY	●	●			●	●		●						●	●
MINNEAPOLIS-ST. PAUL	●	●	●		●	●		●			●				
SEATTLE METRO									●		●	●	●		
SOGREAH	●	●			●	●		●	●	●	●	●	●	●	●
UNIVERSITY OF CINCINNATI	●	●			●	●		●						●	●
UNIVERSITY OF ILLINOIS	●	●			●	●		●	●				●	●	●
UNIVERSITY OF MASSACHUSETTS	●	●			●		●		●					●	●
WATER RESOURCES ENGINEERS	●	●	●		●	●		●	●	●	●	●		●	●
WILSEY AND HAM	●				●	●		●							

PROBLEMS IN URBAN DRAINAGE MODELLING

The gap between the state of the art of modelling and the methods used in practical applications is reasonably common to other areas in water resources. One of the causes, as indicated by McPherson [5], is that most of the studies are concerned with the improvement of tools rather than with the solving of problems. Another cause is that many attempts to use new models do not follow some of the basic rules of model implementation, discussed by Biswas [6], such as:

1. Start with a simple model and keep it simple.
2. In general, it is worthwhile not to build generalized all-purpose models.
3. The chances of a model being used are greatly advanced if good documentation is available.
4. Modelling and data collection process should proceed in parallel.

Various problems associated with implementation of drainage modelling techniques have been discussed by Walesh [1], principally:

1. There is a lack of reliable data concerning the cost of application of existing models and the costs of associated activities such as data collection and preparation.
2. The additional benefits resulting from model application have rarely been assessed, so the value of modelling has not been established on a cost-benefit basis.
3. Many existing models cannot be practicably used by small consulting firms or small government agencies because of lack of staff members, low probability of repeated model uses, and other factors.

While many studies have been concerned with the description, testing and comparison of the models listed in Table 1, it is felt that for a practising engineer, the important decision is whether to use the Rational Method or a more sophisticated hydrograph method incorporating, for example, some form of flow routing. Based on the experience of several Canadian studies on model testing, and many model applications in different drainage problems [7] (see Table 2), this paper will attempt to outline some of the technical and nontechnical considerations for selection

TABLE 2. COMPARISON OF SWMM AND RATIONAL METHOD FOR TEST CATCHMENTS

Catchment	Area (acres)	Imperviousness (%)	No. of Storms	Parameter	Rational Method λ	Rational Method σ	Rational Method ϵ	SWMM λ	SWMM σ	SWMM ϵ
Oakdale Ave. Chicago	12.95	45.8	14-17	Peak discharge	1.40	0.58	46	1.08	0.20	19
Gray Haven, Baltimore	23.3	52	10-14	Peak discharge	0.91	0.22	20	1.18	0.22	19
Calvin Park, Kingston	89.4	27	10-13	Peak discharge	1.63	0.28	63	1.20	0.22	28

λ is the mean ratio computed/measured of the parameter.

σ is the standard deviation of the individual values about.

ϵ is the mean absolute percentage error.

between the two basic techniques in urban drainage - the Rational Method and Hydrograph Models.

URBAN RUNOFF MODELS

The Rational Method, which is the simplest runoff model, calculates peak storm water runoff rates according to the following formula:

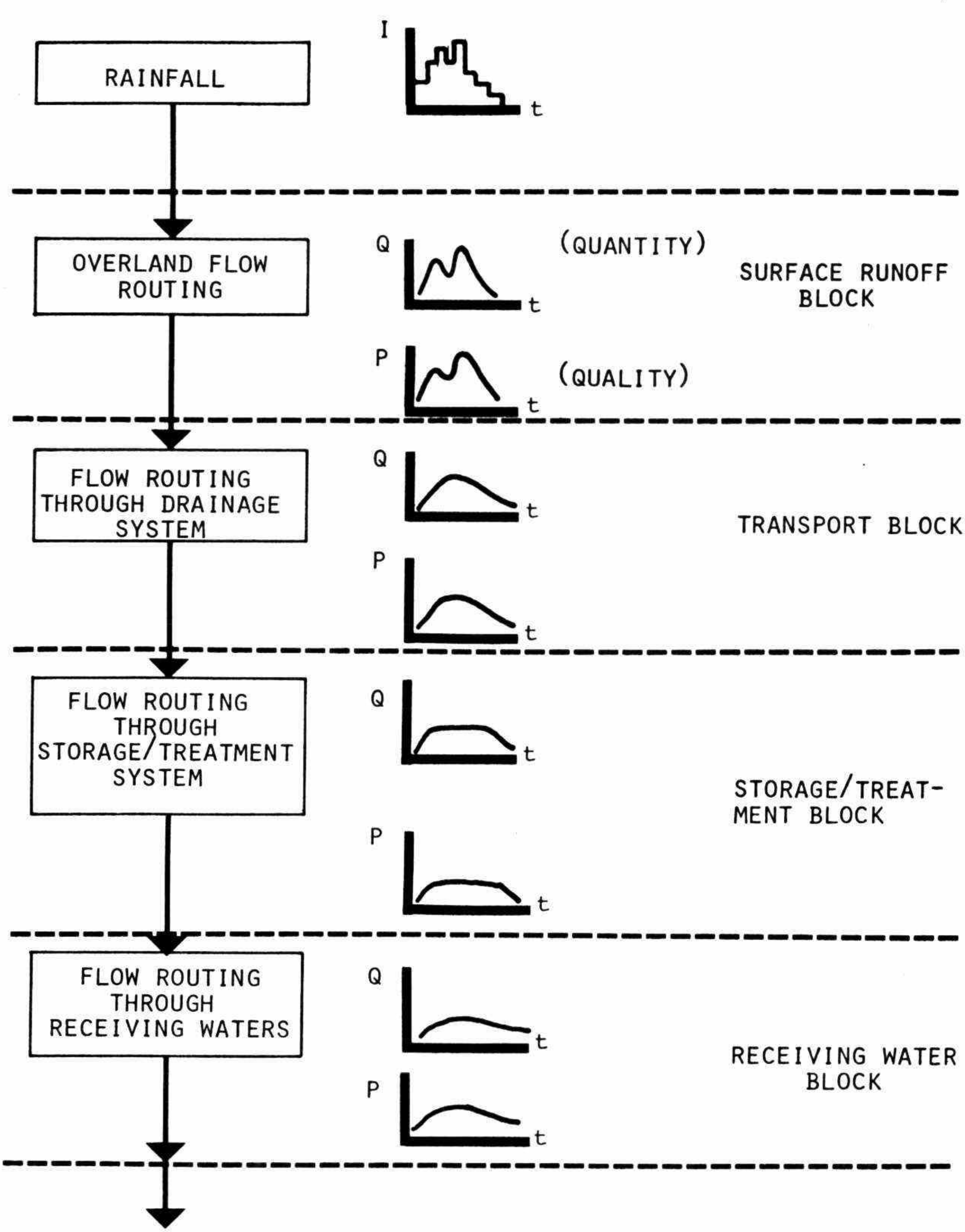
$$Q = Ci_{ave}A$$

where: Q is the peak runoff rate (cfs),
A is the tributary drainage area (acres),
i_{ave} is the average rainfall intensity (in/hr) for the time of concentration,
and C is an empirical runoff coefficient.

The properties of this method have been outlined in previous studies [2, 3], and only the major limitations in practice are stated here:

1. The runoff coefficient does not properly account for antecedent conditions, losses during the rainfall event, and in general all the physical factors affecting runoff.
2. The method considers sewer flow routing in a simplistic manner through the time of concentration concept. Non-uniform, unsteady flow in sewers, surcharge and interconnected networks are not accounted for.
3. A complete runoff hydrograph is not developed so the method is unsuitable for the design of drainage systems incorporating storage.

Since 1960, efforts to improve runoff estimation have resulted in a proliferation of urban runoff models, most of which contain separate modules for generation of surface runoff hydrographs and flow routing through the sewer system. An example of a comprehensive model extensively tested in the U.S. [8], Canada [9], and Australia [10] is the U.S. EPA Storm Water Management Model (SWMM). An overview of the model is presented in Figure 1. There are several versions of this model, the most recent one incorporating a more sophisticated sewer hydraulics routine developed by Water Resources Engineers, Inc. (WRE). Backwater effects



OVERVIEW OF THE STORM WATER

MANAGEMENT MODEL

FIG. 1

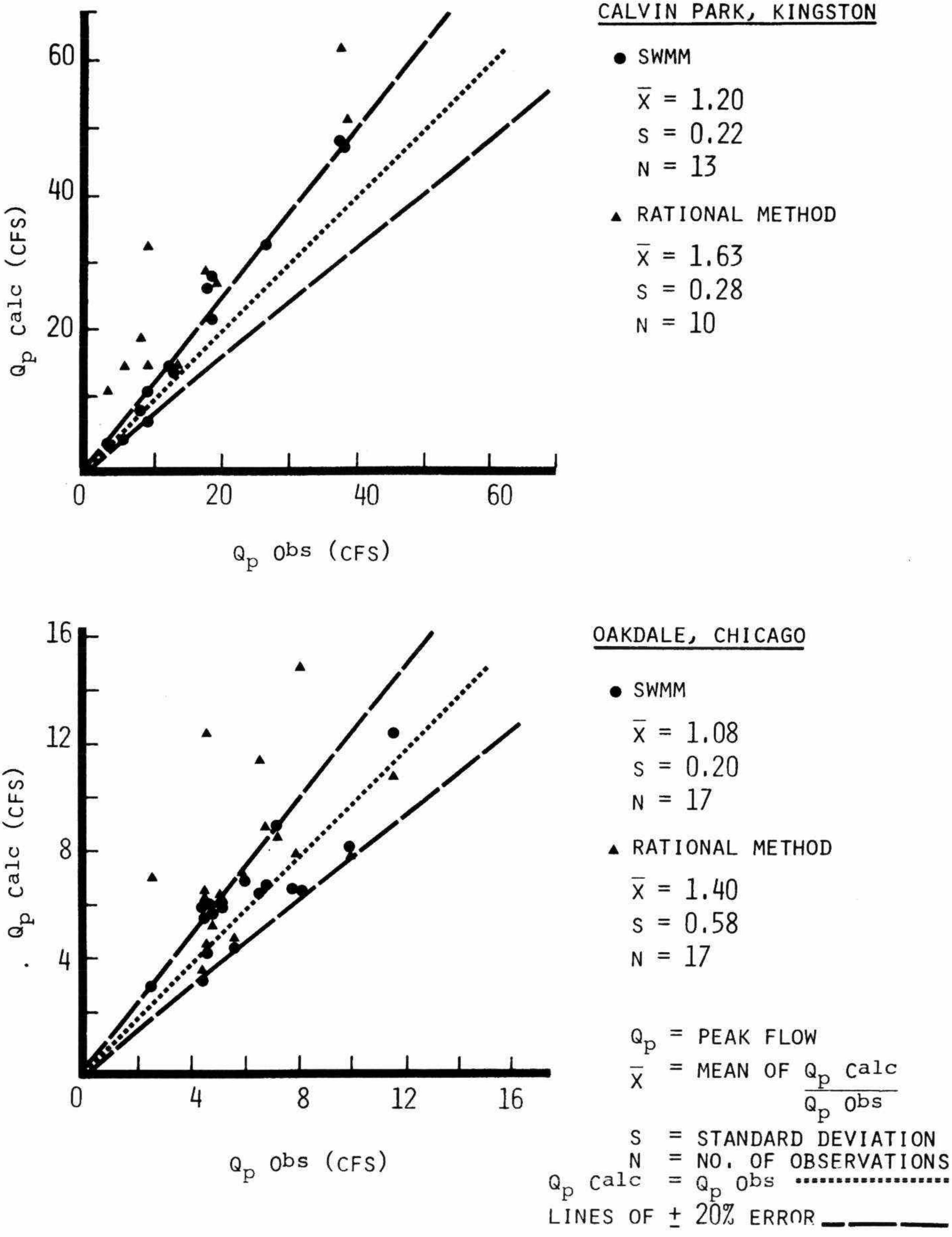
through the sewer system and surcharge conditions are accurately simulated. The routine can also handle interconnected sewer networks and submergence of outfalls by the receiving water. The SWMM contains an optional hydraulic design routine by means of which conduits are sized to accommodate the computed flows without surcharge. Hence, the model may be applied directly in sewer design studies.

The SWMM has recently been studied and tested for the Urban Drainage Subcommittee of the Canada-Ontario Agreement [9], and the comparisons with the Rational Method will be confined to this model. However, similar results could be obtained with other methods, and the reader is referred to Brandstetter [4] for a comparative evaluation of the different models. Also, the paper will consider directly only flow quantity aspects, but it is pointed out that correct hydrograph simulation is a prerequisite for many quality control aspects [9].

COMPARISON OF METHODS FOR FLOW SIMULATION

The most commonly discussed advantage of hydrograph methods is the increased accuracy of flow simulation using a model which can be calibrated and validated by means of measurements. The Rational Method cannot be accurately calibrated since the runoff coefficient varies during a runoff event. The runoffs predicted by the Rational Method and SWMM are compared against measured flows in Figure 2 for two test catchments [3]. Results from several catchments have shown that the Rational Method gives inconsistent estimates of peak flows, either larger or smaller than measured flows, according to antecedent conditions, shape of the watershed, and the pipe system characteristics. Similar inconsistencies have been demonstrated in another study which compared frequency curves based on measurements with peak flows estimated with the Rational Method [11].

Generally, the measured flows are for low intensity storms which did not surcharge the sewer system. When surcharge occurs, for example, during the design storm in some existing systems, the Rational Method cannot adequately predict the system performance because the assumption used in the development of the time of concentration breaks down when any type of in-system storage is used. However, a model such as SWMM-WRE which correctly simulates the hydraulic conditions under



COMPARISON OF RATIONAL METHOD AND SWMM

AGAINST OBSERVED FLOWS

FIG. 2

surcharge will provide an accurate assessment of the system response. Figure 3 shows that the peak outflow from a 171-acre area in which the sewer system was slightly surcharged (generally less than 1 foot) was 40 percent less than the Rational Method estimate. In Figure 4, the hydrograph from a surcharged area of 820 acres in Winnipeg is compared with the hydrograph based on re-sizing existing pipes for free-flow conditions. These results indicate that use of the Rational Method may lead to substantial errors under surcharge conditions.

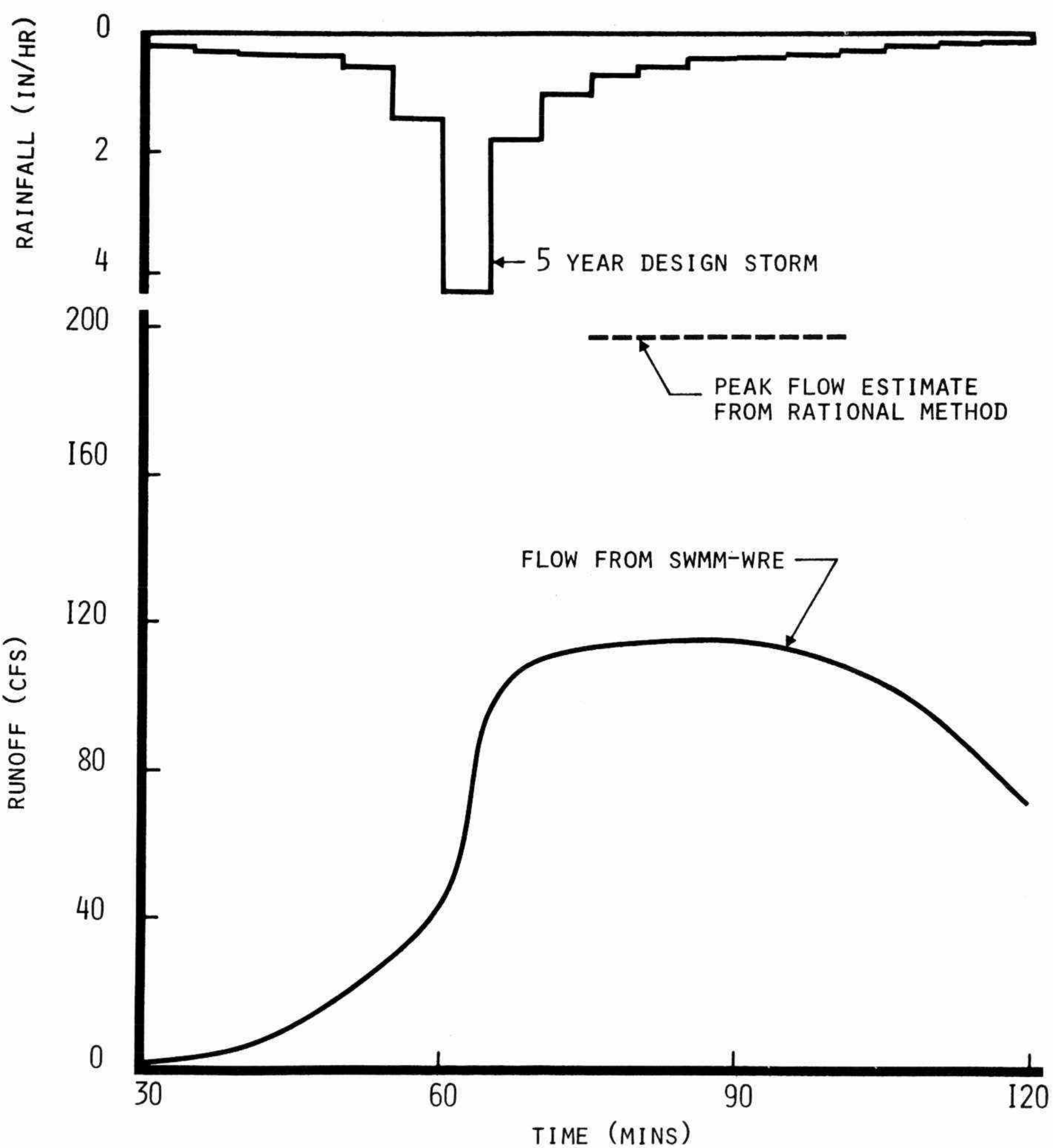
COMPARISON OF METHODS FOR DESIGN APPLICATION

There are certain applications in urban drainage for which the need for sophisticated modelling techniques has clearly been established. These applications relate mainly to pollution control studies such as real time control of trunk sewer systems to limit combined sewer overflow from large metropolitan areas, comparison of combined sewer separation with storage/treatment of overflows, etc. However, the large majority of drainage studies are concerned with simpler applications such as master drainage planning, design of storm drainage systems for new subdivisions, design of trunk sewers and relief of overloaded systems. It is in these areas that the advantages of models have yet to be ascertained.

Analysis of Existing Sewer Systems and Design of Relief Alternatives

The traditional approach to analysis of overloaded sewer systems has been to compare the design flows estimated by the Rational Method with the full-flow capacities of existing pipes. The pipes which are under surcharge are identified, but it is not possible to determine whether the degree of surcharge is acceptable. With analysis methods such as SWMM-WRE, water levels are determined throughout the system. These levels are then compared with safe levels, e.g. basement elevations in a combined system, to identify the locations of existing system inadequacies. The advantage of this information is that it is possible to identify priorities in the design of relief sewers, mainly in defining the staging of investments between laterals and trunk sewers.

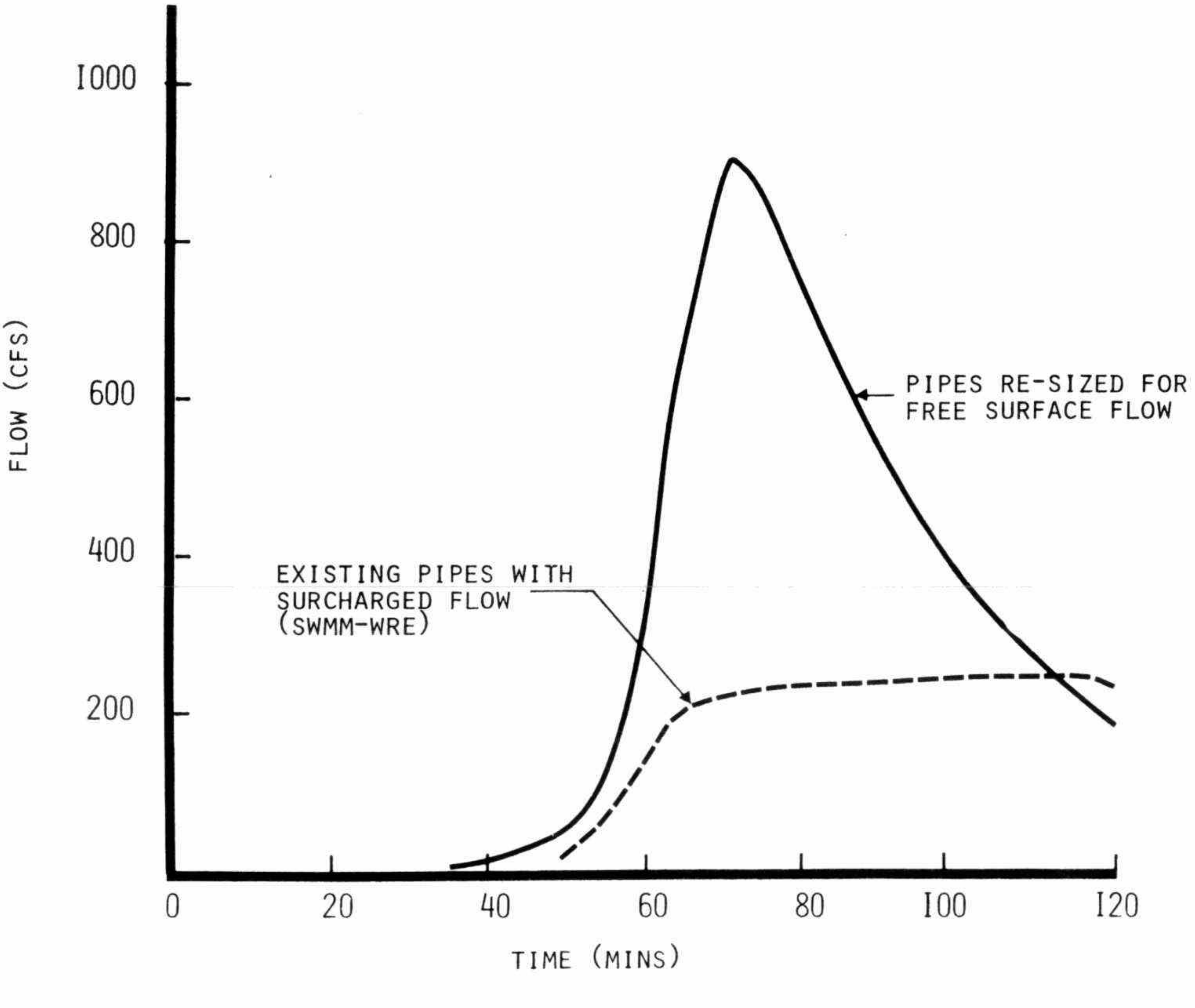
The capability of SWMM-WRE to account for cross-connections, which redistribute surcharge as indicated in Figure 5, can be utilized to design economic relief systems based on interconnecting sewers or cut-off



AREA = 171 ACRES
IMPERVIOUSNESS = 44%

RUNOFF FROM STORM DRAINAGE DISTRICT UNDER SURCHARGE CONDITIONS FOR 5 YEAR STORM

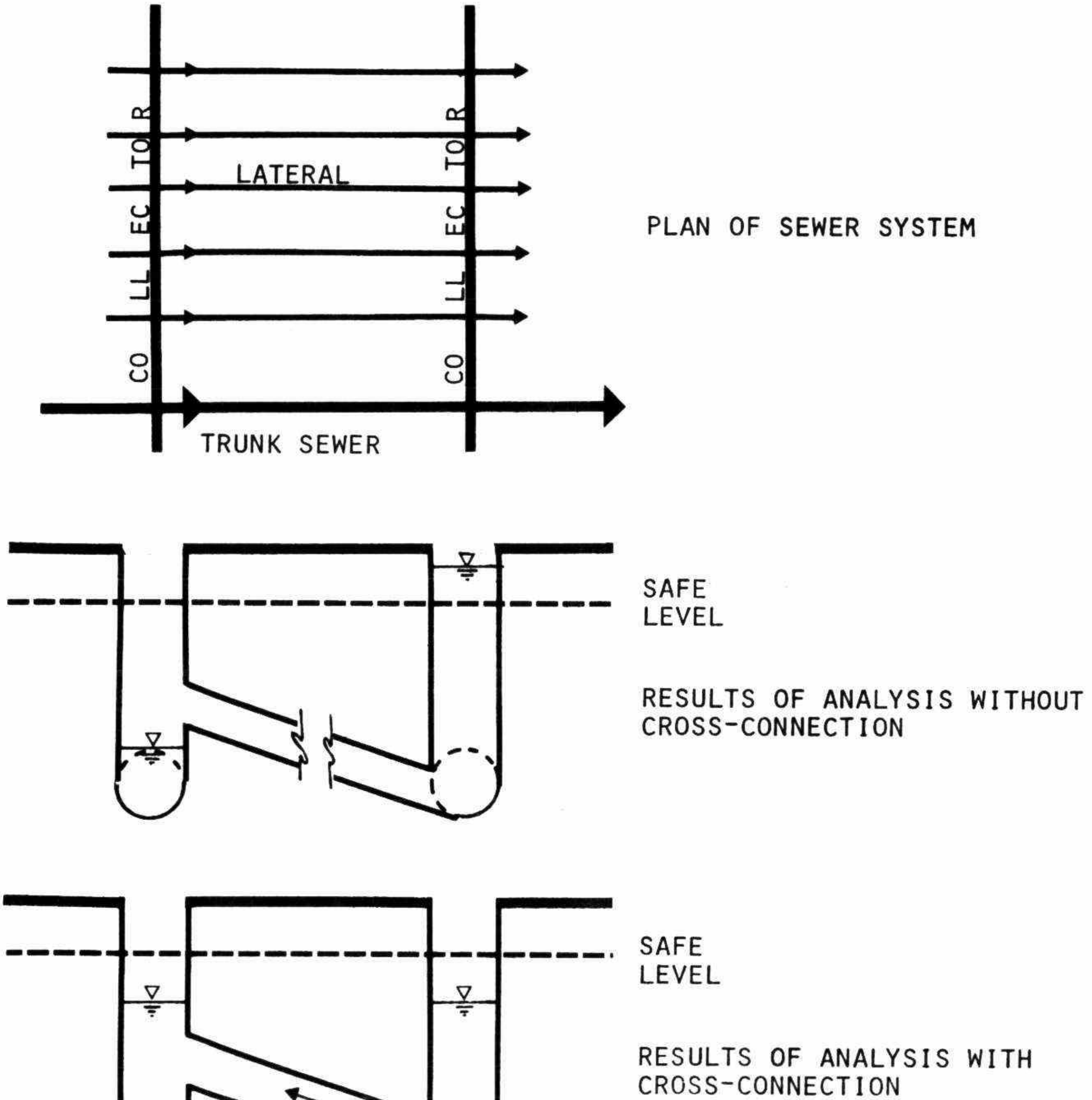
FIG. 3



EFFECT OF SURCHARGE ON OUTFLOW HYDROGRAPH

FROM COMBINED SEWER DISTRICT FOR 5-YEAR STORM

FIG. 4


COLLECTOR
LATERAL
COLLECTOR
TRUNK SEWER
PLAN OF SEWER SYSTEM
SAFE LEVEL
RESULTS OF ANALYSIS WITHOUT CROSS-CONNECTION
SAFE LEVEL
RESULTS OF ANALYSIS WITH CROSS-CONNECTION

EFFECT OF CROSS-CONNECTION

IN SURCHARGED SYSTEM

FIG. 5

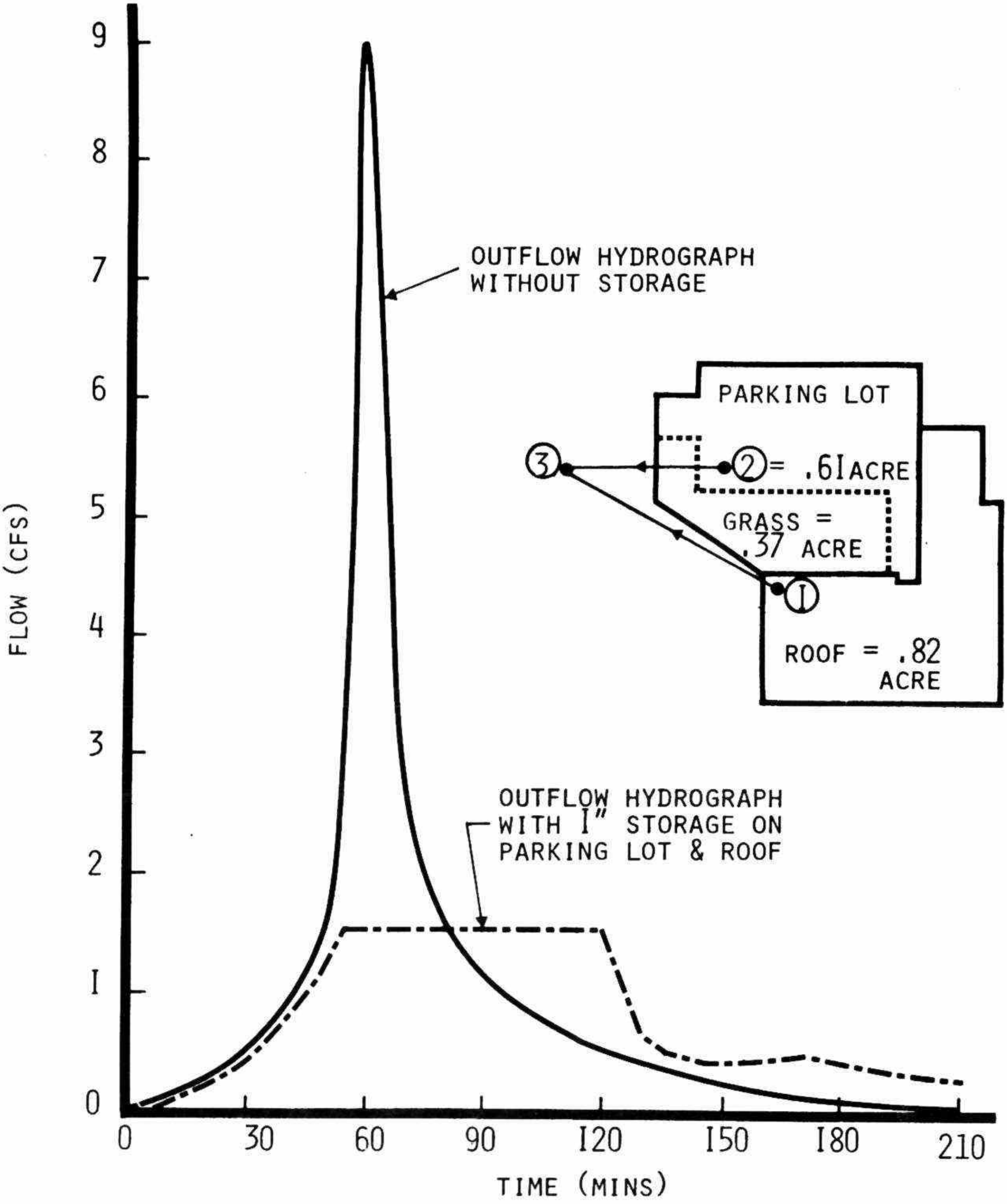
sewers. This approach in a combined sewer district of Winnipeg yielded a cost saving of 60 percent over traditional methods [12]. The allowance of a small surcharge represents a management technique to better utilize in-line storage so that substantial reductions in pipe size are possible.

Detention Storage

Other types of storage may also have substantial economic benefits. Figure 6 indicates the effect of temporary ponding on the roof and parking lot of a shopping centre on the outflow hydrograph. The reduced outflow may satisfy the maximum allowable inlet requirement for an existing drainage system or can provide size reductions for a new system. The incorporation of storage ponds in drainage systems for new subdivisions, as shown schematically in Figure 7, can have aesthetic and environmental benefits as well as economic advantages. For this particular situation, the peak flow for a development of 61 acres was reduced from 220 cfs to 20 cfs. Similar results could be obtained by a holding tank. The volume of storage determined by SWMM was 20 percent smaller than that determined by an approximate method [13]. Since the development of runoff hydrographs is required for evaluation of storage alternatives, the models have definite advantages for these applications.

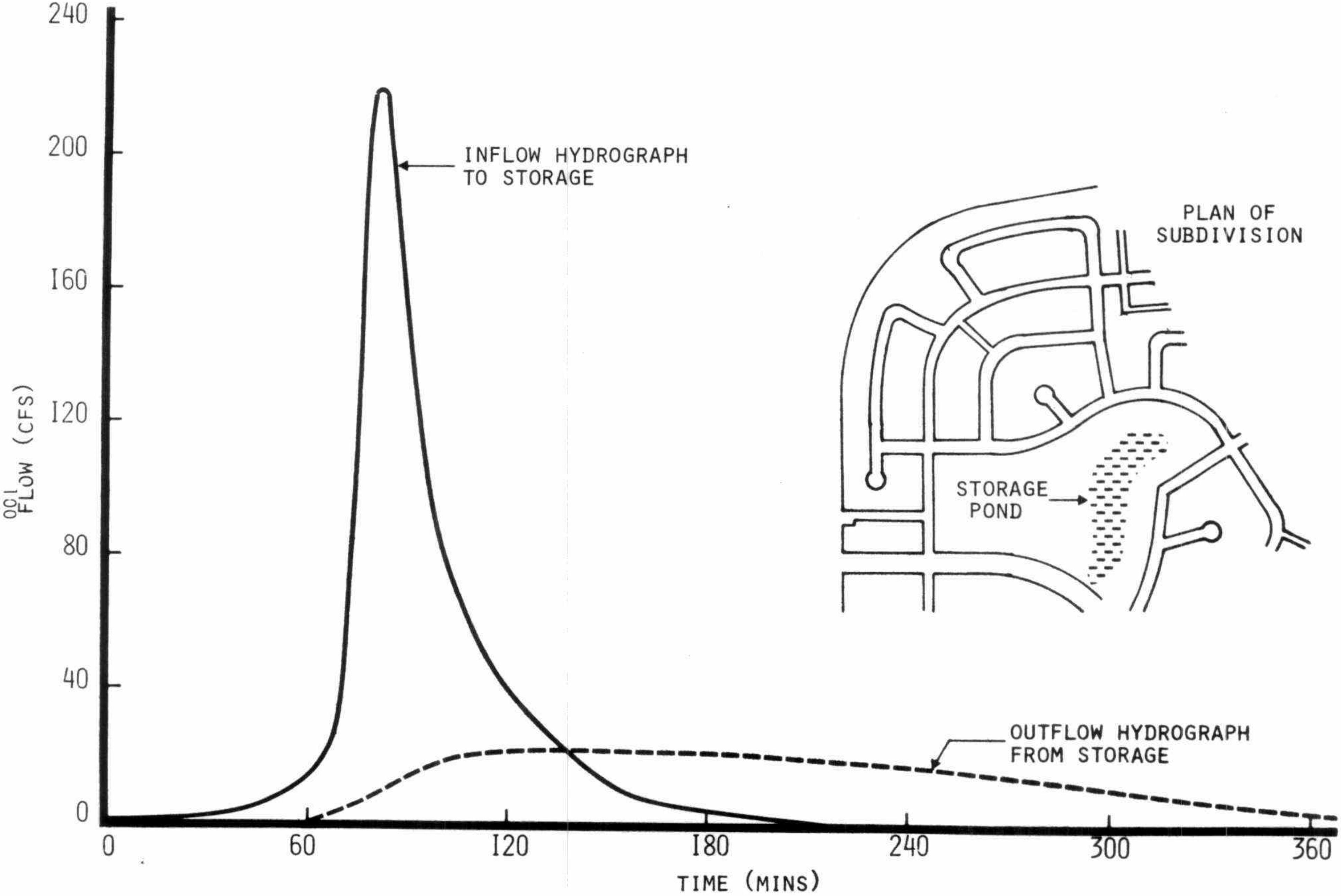
Master Drainage Planning

In the area of master drainage planning, criteria are being developed to limit the environmental impacts of drainage. These criteria generally require that the runoff increase resulting from urbanization be minimized and that the pollution from urban runoff be controlled. Comparison of runoff hydrographs before and after development and simulation of pollutant washoff will be required to provide the necessary information. Clearly, this type of study is possible only with the use of hydrologic models. Modelling was used in a master drainage study of a 4,000 acre urbanizing area upstream of Metropolitan Toronto. Studies for a sub-watershed led to the recommendation of two storage ponds, with total area of about 10 acres, which will reduce the post-development runoff rates from a large part of the area from 2,100 cfs for a 25 year storm to pre-development rates of 630 cfs. Drainage models of new areas under development may also be applied and refined as part of the total urban



EFFECT OF TEMPORARY PONDING ON ROOF AND PARKING LOT ON OUTFLOW HYDROGRAPH

FIG. 6



EFFECT OF STORAGE POND ON RUNOFF FROM
61 ACRE SUBDIVISION FOR 25 YEAR STORM

FIG. 7

planning process to compare the effects of different land use alternatives [14].

Flow Simulation for Trunk and Interceptor Sewers

The capability of models to reproduce routing conditions is best utilized in simulation of flows in the trunk sewers and interceptors of large drainage areas. In a recent application in Canada [15], it was possible to model the flows in the major lines of a combined sewer system for 11,000 acres, accounting for significant surcharge, interconnections, diversion structures and overflows. The Rational Method was an unsuitable tool for analysis of this complex system and in some locations, the method would lead to order-of-magnitude errors in flow estimation. The modelling study led to significant savings by identification of problem areas and recommendations for flooding control by relief of lateral sewers and pollution abatement by real-time control of trunk and interceptor sewers.

The above examples are intended to demonstrate the potential economic benefits of using modelling techniques in conjunction with modern concepts of storm water management. Although other examples have been given, there is at present a lack of reliable information concerning all the benefits of modelling relative to traditional approaches for a wide range of applications. It is considered that a systematic study is required to ascertain these benefits, so that practitioners may have a clear picture of the value of modelling.

CONSTRAINTS IN MODEL APPLICATIONS

An important problem in the selection of new models versus traditional techniques is the cost of modelling. In a drainage study utilizing models, many activities such as data collection, development of alternatives and report writing generally cost little more than in a study where the analysis is based on the Rational Method. The following table gives coarse estimates of study costs (both the total cost and the cost of modelling) for different types of drainage studies.

If an average capital cost of $5,000 per acre is assumed for storm drainage, the following estimates indicate that the cost of modelling is generally less than 0.2 percent of the capital cost. The examples presented

	Study Cost ($/Acre)	
	Total	Modelling
1. Master drainage plan for small community (5000 persons)	18-22	5-8
2. Preliminary master drainage plan for large new development (4000-5000 acres)	4-6	2-3
3. Detailed analysis of relief sewers for sewer districts (200-1000 acres)	20-35	6-10
4. General analysis of trunk sewers for a large city (10,000 acres).	4-6	2-3

in previous sections (Figures 3, 4, 6 and 7) demonstrate that some storm water management alternatives may provide significant reductions in design flows. Experience in a range of studies has indicated that the reduced design flows lead to significant savings in capital costs, so that the return from modelling is substantial. In certain cases when the modelling costs are higher than shown above, e.g. detailed analysis of several alternatives for a small drainage area, the extra costs are justified through increased returns.

The above cost estimates are intended as guidelines based on previous experience in modelling studies. They assume staff expertise, computer accessibility and other facilities that might be present only in specialized groups. When an organization is investigating implementation of models, recovery of the front-end costs over a number of future projects must be considered.

The cost of training staff is related to the object of training. Most potential users are interested in a basic understanding of modelling principles, selection of models, and monitoring of studies performed by specialized groups such as consultants. Seminars organized by the Canadian Urban Drainage Subcommittee and the U.S. Environmental Protection Agency have covered most aspects of modelling, including numerical examples, in three to five days. Experience with municipalities such as Winnipeg and

Edmonton has shown that staff engineers can conduct independent modelling studies after working jointly with an experienced team for several months.

It seems, therefore, that the total cost of model implementation in urban drainage need not be excessive. Many of the difficulties in model implementation have probably resulted from violation of the rules proposed by Biswas (see Introduction). In particular, the promotion of many models may be confusing to those involved for the first time in these activities. In some of the recent studies sponsored by the Canadian Urban Drainage Subcommittee, the writers and those associated in this work have attempted to follow some of the rules [7, 9]. The most recent study was concentrated on SWMM, which was simplified to meet user needs and constraints by development of coarse modelling approaches and independent quality routines. A hierarchical procedure of interfacing the simplified STORM model used for screening of drainage alternatives with SWMM was proposed and demonstrated. The models were also tested on Canadian watersheds and documented in a user's manual [9].

CONCLUSION

Comparison of urban runoff models with the Rational Method must be based not only on accuracy of flow simulation but also on the scope of drainage studies offered by the different methods. For example, if the Rational Method is used in the drainage system design for a new development, the designer is limited to a traditional concept of pipes sized for free-surface flow and rapid removal of runoff without consideration of downstream runoff increases and environmental effects. However, if the design is oriented towards management of runoff considering retardation, storage, etc. in order to develop a drainage system which is both economical and environmentally sound, modelling is required to assist the designer in determining the best solution.

While recent activities by different agencies, municipalities and consultants have led to implementation of runoff models as tools for practical solution of urban drainage problems, further effort is required to improve the availability and effectiveness of modelling techniques at all levels of engineering practice. Efforts to remove the nontechnical constraints to further model implementation should include identification and documentation of the benefits and costs of modelling, the requirements for staff training and organization of technical assistance.

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RUNOFF BLOCK

WORKSHOP

STEPS IN SETTING UP A COMPUTER SIMULATION

1. Select model best suited to application.
2. Obtain required data:
   - accurate rainfall records,
   - details of physical system, sewer plans,
   - hydrologic characteristics (imperviousness, infiltration, etc.),
   - additional data sometimes useful or necessary:
     - topographic mapping,
     - aerial photographs,
     - land use plans,
     - field inspection or measurements,
     - construction drawings (special structures).
3. Establish degree of detail required or possible:
   - minimum pipe size,
   - computer storage,
   - design or planning.
4. Define drainage boundaries and inlet locations according to criteria in Step 3,
   - Set up logical numbering system.
5. Prepare pipe and subcatchment data according to model input requirements:
   - imperviousness,
   - areas, widths (SWMM),
   - surface slopes,
   - conduit lengths, diameters, slopes,
   - quality data, erosion, etc.
6. Code and keypunch data.
7. Carefully check data, test runs.
8. Begin production runs.

METHODOLOGY OF PREPARING DETAILED SUBCATCHMENT DATA

A. IMPERVIOUSNESS

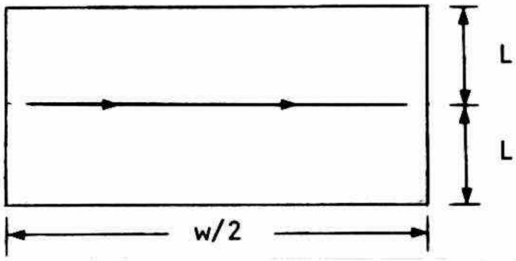
IMPERVIOUS AREAS:
- paved streets and laneways,
- paved driveways,
- directly connected roofs.

PERVIOUS AREAS :
- unpaved surfaces,
- roofs and paved surfaces which drain onto adjacent pervious surfaces.

COMPUTATION OF IMPERVIOUSNESS:

STREET AREA = avg. width x length.
DRIVEWAY AREA = avg. surface x no. of driveways.
ROOF AREA = avg. surface area x no. of roofs.

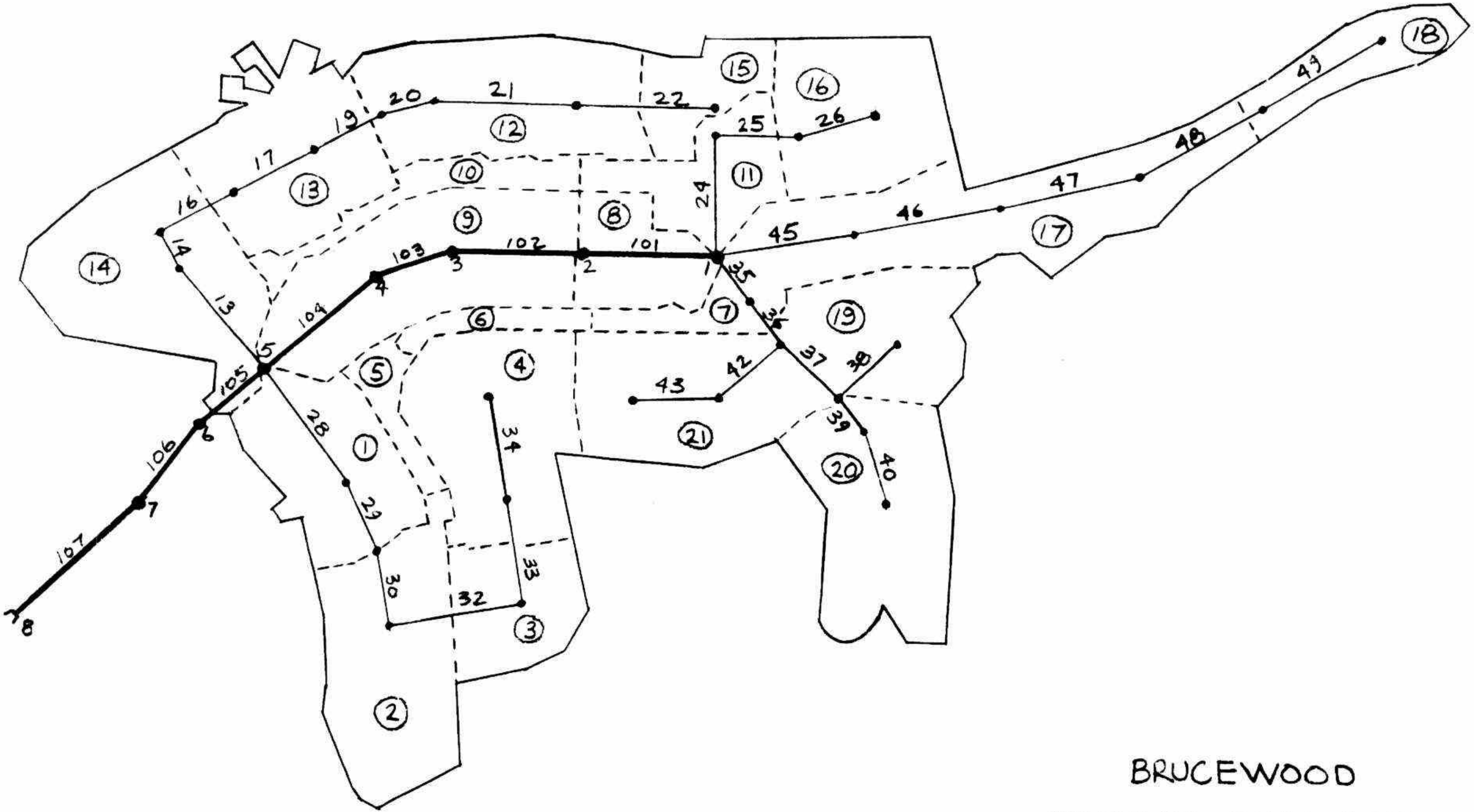
B. OVERLAND FLOW WIDTH



Avg. Length of overland flow path is measured.

$$\text{width} = \frac{\text{avg. length}}{\text{total area}} = \frac{L}{A}$$

(PROGRAM ALGORITHM ASSUMES ALL SUBCATCHMENTS ARE RECTANGULAR.)



BRUCEWOOD
DETAILED SCHEMATIC

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SWMM WORKSHOP

BRUCEWOOD ; STORM Aug 29, 75

SUBMITTED BY M.A

JOB NUMBER 10680

PAGE NO. 1/5

RUNOFF BLOCK DATA INPUT

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GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SWMM WORKSHOP

BRUCEWOOD, STORM Aug 29, 1975

SUBMITTED BY M.A

JOB NUMBER 10680

PAGE NO. 2/5

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GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

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11		1	1	2.		8.40				.0057				

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SUBMITTED BY M. A

JOB NUMBER 10680

PAGE NO. 4/5

	1–5	6–10	11–15	16–20	21–25	31–35	51–55
		2	1		3.	11.15	.0057
		3	1		5.	5.35	.0057
		4	1		2.	10.85	.0057
		5	5		1.	.10	.0057
		6	5		1.	.10	.0057
		7	5		1.	1.70	.0057
		8	1		2.	6.00	.0057
		9	1		6.	14.50	.0057
		10	5		1.	.10	.0057
		11	1		4.	4.40	.0057
11		12	1		3.	11.40	.0057
5 (con'td)		13	1		3.	10.55	.0057
		14	1		7.	15.00	.0057
		15	1		3.	5.40	.0057
		16	1		1.	7.80	.0057
		17	1		12.	23.05	.0057
		18	1		6.	8.80	.0057
		19	1		2.	7.20	.0057
		20	1		6.	8.80	.0057
		21	1		4.	8.40	.0057
12	5	1					
13	47	160	21	30	40		

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SUBMITTED BY M·A

JOB NUMBER 10680

PAGE NO. 5/5

TRANSPORT BLOCK DATA INPUT

CARD GROUP	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70
11	BRUCE WOOD QUANTITY AND QUALITY SIMULATION - SWMM WORKSHOP													
12	15	8.0	3	3	8	1	0	3	4					
13		300.		.0001		2								
14	0	0	0	1	0	0								
15	1	0		16										
	2	101		16										
	3	102		16										
	4	103		16										
	5	104		16										
	6	105		16										
	7	106		16										
	8	107		16										
116	101	1		1	278.1		3.25		0.33					1.
	102	2		1	238.8		3.25		0.43					
	103	3		1	108.7		3.25		0.51					
	104	4		1	296.1		3.25		0.48					
	105	5		1	178.7		3.25		1.14					
	106	6		1	222.0		3.25		1.40					
	107	7		1	325.0		3.25		0.75					
27	8													
29	1	3	5											
30	1	2	3	4	5	6	7	8						

```
          BRUCEWOOD QUANTITY AND QUALITY SIMULATION -  SWMM WORKSHOP

             STORM OF AUGUST 29,1975 --F  NED  &R & I &  &N



     BASIN NUMBER    1

     NUMBER OF TIME STEPS    80

     INTEGRATION TIME INTERVAL (MINUTES),      5.00

     25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

     FOR  70 RAINFALL STEPS, THE TIME INTERVAL IS    5.00 MINUTES

     FOR RAINGAGE NUMBER  1,  RAINFALL HISTORY IS

          0.24      0.0       0.0       0.0       0.0       0.0       0.0       0.12      0.0       0.12
          0.12      0.24      0.0       0.12      0.12      0.12      0.0       0.12      0.0       0.12
          0.0       0.12      0.0       0.0       0.12      0.0       0.0       0.12      0.0       0.12
          0.12      0.0       0.0       0.12      0.0       0.0       0.0       0.0       0.0       0.0
          0.0       0.0       0.0       0.12      0.0       0.0       0.24      0.12      0.0       0.0
          0.12      0.12      0.24      0.12      0.12      0.12      0.12      0.36      0.24      0.12
          0.12      0.12      0.0       0.12      0.12      0.12      0.12      0.0       0.12      0.0
```

```
* * * * *  G U T T E R   A N D   P I P E   D A T A  * * * * *

GUTTER       GUTTER         WIDTH      LENGTH      SLOPE     SIDE SLOPES      MANNING      OVERFLOW
NUMBER     CONNECTION        (FT)       (FT)      (FT/FT)      L      R          N            (IN)

  1  *  28        5           2.0        291.       0.007      0.0    0.0       0.018        10.00
  2  *  29       28           2.0        161.       0.003      0.0    0.0       0.018        10.00
  3  *  30       29           2.0        160.       0.005      0.0    0.0       0.018        10.00
  4  *  33       32           1.3        220.       0.016      0.0    0.0       0.018        10.00
  5  *  32       30           1.8        286.       0.004      0.0    0.0       0.018        10.00
  6  *  34       33           1.0        219.       0.017      0.0    0.0       0.018        10.00
  7  * 150        5           1.0        230.       0.005      0.0    0.0       0.018        10.00
  8  * 160      150           1.0         85.       0.005      0.0    0.0       0.018        10.00
  9  *  35        1           2.3        127.       0.004      0.0    0.0       0.018        10.00
 10  * 110        5           1.0        190.       0.005      0.0    0.0       0.018        10.00
 11  *  24        1           1.5        248.       0.035      0.0    0.0       0.018        10.00
 12  *  19       17           1.3        169.       0.007      0.0    0.0       0.018        10.00
 13  *  21       20           1.0        293.       0.010      0.0    0.0       0.018        10.00
 14  *  20       19           1.0        105.       0.008      0.0    0.0       0.018        10.00
 15  *  17       16           1.5        184.       0.005      0.0    0.0       0.018        10.00
 16  *  16       14           1.5        184.       0.008      0.0    0.0       0.018        10.00
 17  *  14       13           1.8         98.       0.009      0.0    0.0       0.018        10.00
 18  *  13        5           1.8        265.       0.004      0.0    0.0       0.018        10.00
 19  *  22       21           0.8        294.       0.008      0.0    0.0       0.018        10.00
 20  *  26       25           1.3        167.       0.010      0.0    0.0       0.018        10.00
 21  *  25       24           1.5        179.       0.009      0.0    0.0       0.018        10.00
 22  *  48       47           1.0        300.       0.040      0.0    0.0       0.018        10.00
 23  *  49       48           1.0        300.       0.020      0.0    0.0       0.018        10.00
 24  *  45        1           2.3        300.       0.003      0.0    0.0       0.018        10.00
 25  *  46       45           2.3        300.       0.003      0.0    0.0       0.018        10.00
 26  *  47       46           1.5        300.       0.020      0.0    0.0       0.018        10.00
 27  *  38       37           1.0        169.       0.014      0.0    0.0       0.018        10.00
 28  *  37       36           2.3        165.       0.005      0.0    0.0       0.018        10.00
 29  *  36       35           2.3        106.       0.006      0.0    0.0       0.018        10.00
 30  *  40       39           1.3        154.       0.015      0.0    0.0       0.018        10.00
 31  *  39       37           1.8         89.       0.011      0.0    0.0       0.018        10.00
 32  *  43       42           1.3        194.       0.007      0.0    0.0       0.018        10.00
 33  *  42       36           1.5        171.       0.006      0.0    0.0       0.018        10.00

TOTAL NUMBER OF GUTTERS/PIPES,  33

ASTERISK (*) DENOTES CIRCULAR PIPE, DIAMETER=.WIDTH.
```

```
* * * * *   S U B C A T C H M E N T   D A T A   * * * * *

SUBCATCH-  GUTTER    WIDTH    AREA   PERCENT     SLOPE    RESISTANCE FACTOR  SURFACE STORAGE(IN)    INFILTRATION   DECAY RATE  GAGE
MENT NO.  OR INLET   (FT)     (AC)   IMPERV.   (FT/FT)    IMPERV.    PERV.   IMPERV.     PERV.      RATE(IN/HR)      (1/SEC)    NO.
                                                                                                 MAXIMUM MINIMUM
   1    1     28     879.0     2.2    64.0      0.028      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   2    2     30    1205.0     3.3    53.0      0.019      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   3    3     32     626.0     1.6    58.0      0.018      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   4    4     34    1212.0     3.1    61.0      0.023      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   5    5    150      70.0     0.6     0.0      0.041      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   6    6    160      45.0     0.6     0.0      0.020      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   7    7     35      60.0     0.5     0.0      0.023      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   8    8      1     711.0     1.5    56.0      0.023      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
   9    9      3    1589.0     3.8    58.0      0.024      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  10   10    110      50.0     0.9     0.0      0.029      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  11   11     24     805.0     1.6    27.0      0.041      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  12   12     21    1162.0     2.8    74.0      0.030      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  13   13     17     928.0     2.8    59.0      0.038      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  14   14     13    1394.0     3.5    71.0      0.042      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  15   15     22     470.0     1.1    67.0      0.024      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  16   16     26     694.0     2.5    50.0      0.023      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  17   17     47    2726.0     4.4    27.0      0.238      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  18   18     49    1481.0     1.2    40.0      0.200      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  19   19     38    1282.0     3.7    27.0      0.026      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  20   20     40    1039.0     3.1    52.0      0.044      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1
  21   21     43    1307.0     3.6    40.0      0.047      0.013     0.250    0.062      0.184     3.00     0.52     0.00115      1

TOTAL NUMBER OF SUBCATCHMENTS,  21

TOTAL TRIBUTARY AREA (ACRES),   48.23
```

```
ARRANGEMENT OF SUBCATCHMENTS AND GUTTERS/PIPES

      GUTTER    TRIBUTARY GUTTER/PIPE                                           TRIBUTARY SUBAREA
      OR PIPE

        28        29                                                              1
        29        30
        30        32                                                              2
        33        34
        32        33                                                              3
        34                                                                        4
       150       160                                                              5
       160                                                                        6
        35        36                                                              7
       110                                                                       10
        24        25                                                             11
        19        20
        21        22                                                             12
        20        21
        17        19                                                             13
        16        17
        14        16
        13        14                                                             14
        22                                                                       15
        26                                                                       16
        25        26
        48        49
        49                                                                       18
        45        46
        46        47
        47        48                                                             17
        38                                                                       19
        37        38    39
```

```
 36        37   42
 40                                                            20
 39        40
 43                                                            21
 42        43
INLET     TRIBUTARY GUTTERS AND/OR PIPES                   TRIBUTARY SUBAREAS
  5        28  150  110   13
  1        35   24   45                                         8
  3                                                             9
```

```
HYDROGRAPHS WILL BE STORED FOR THE FOLLOWING   3 INLETS
                    5     1     3
```

```
                 QUALITY DEFAULT PARAMETER CHANGES

                 NQS= 10

      DDFACT     0.70000       2.3000       3.3000       4.6000       1.5000

      SET-S      100.00        100.00       100.00       100.00       100.00
      SUS-S      1000.0        1000.0       1000.0       1000.0       1000.0
      COLIF      0.65000E 07   0.27000E 07  0.17000E 07  0.10000E 07  0.0
      BOD        5.0000        3.6000       7.7000       3.1200       5.0000
      COD        40.000        40.000       39.000       40.000       20.000
      NIT        0.48000       0.61000      0.41000      0.43000      0.50000E-01
      PO4        0.50000E-01   0.50000E-01  0.70000E-01  0.30000E-01  0.30000E-01
      GREASE     1.0000        1.0000       1.0000       1.0000       1.0000
      PB         0.0           0.0          0.0          0.0          0.0
      CL         0.0           0.0          0.0          0.0          0.0




          .....QUALITY SIMULATION INCLUDED IN THIS RUN.....


          INPUT PARAMETERS AS FOLLOWS


          NUMBER OF CONSTITUENTS        10

          NUMBER OF DRY DAYS           2.0

          STREET CLEANING FREQ        14.0 DAYS

          PASSES PER CLEANING            1

          STD CATCHBASIN VOLUME      20.00 FT3

          CATCHBASIN CONTENTS BOD     60.0 MG/L

          METHOD FOR CALCULATING SS:
            SPECIAL TECHNIQUE.
            SAME AS IN ORIGINAL
            RELEASE I OF THE SWMM.
            ISS = 1
```

```
WATERSHED QUALITY DEFINITIONS


SUBAREA    LAND USE    TOTAL  GUTTER        NUMBER  OF
 NUMBER     CLASS.   LENGTH*10**2 FT.   CATCHBASINS

 1     1       1            8.40              2.00
 2     2       1           11.15              3.00
 3     3       1            5.35              5.00
 4     4       1           10.85              2.00
 5     5       5            0.10              1.00
 6     6       5            0.10              1.00
 7     7       5            1.70              1.00
 8     8       1            6.00              2.00
 9     9       1           14.50              6.00
10    10       5            0.10              1.00
11    11       1            4.40              4.00
12    12       1           11.40              3.00
13    13       1           10.55              3.00
14    14       1           15.00              7.00
15    15       1            5.40              3.00
16    16       1            7.80              1.00
17    17       1           23.05             12.00
18    18       1            8.80              6.00
19    19       1            7.20              2.00
20    20       1            8.80              6.00
21    21       1            8.40              4.00
```

```
HYDROGRAPHS WILL BE LISTED FOR THE FOLLOWING   5 GUTTERS OR INLETS

          47  160   21   30   40



TOTAL RAINFALL (CU FT)                          0.752704E 05

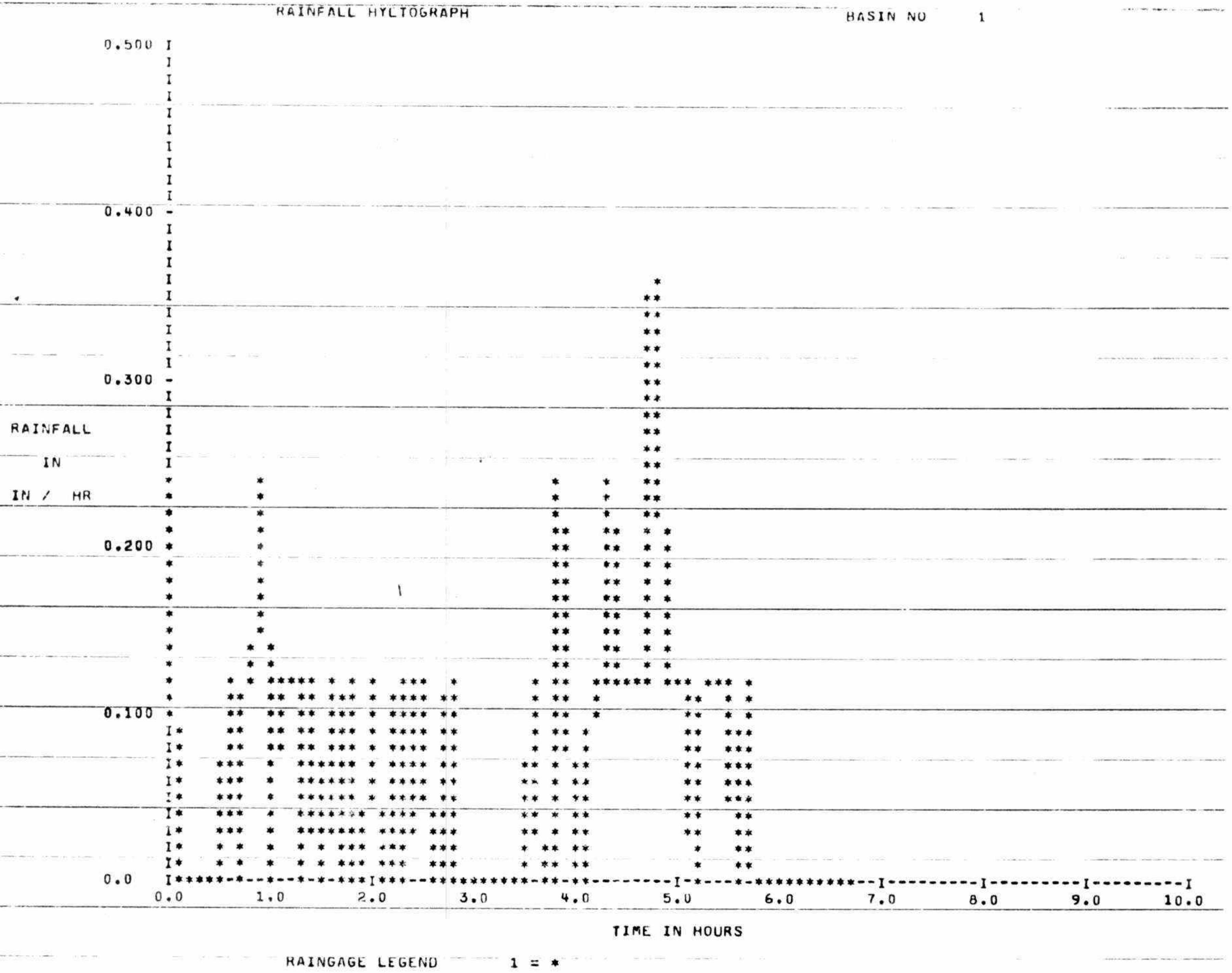
TOTAL INFILTRATION (CU FT)                      0.388491E 05

TOTAL GUTTER FLOW AT INLET (CU FT)              0.324648E 05

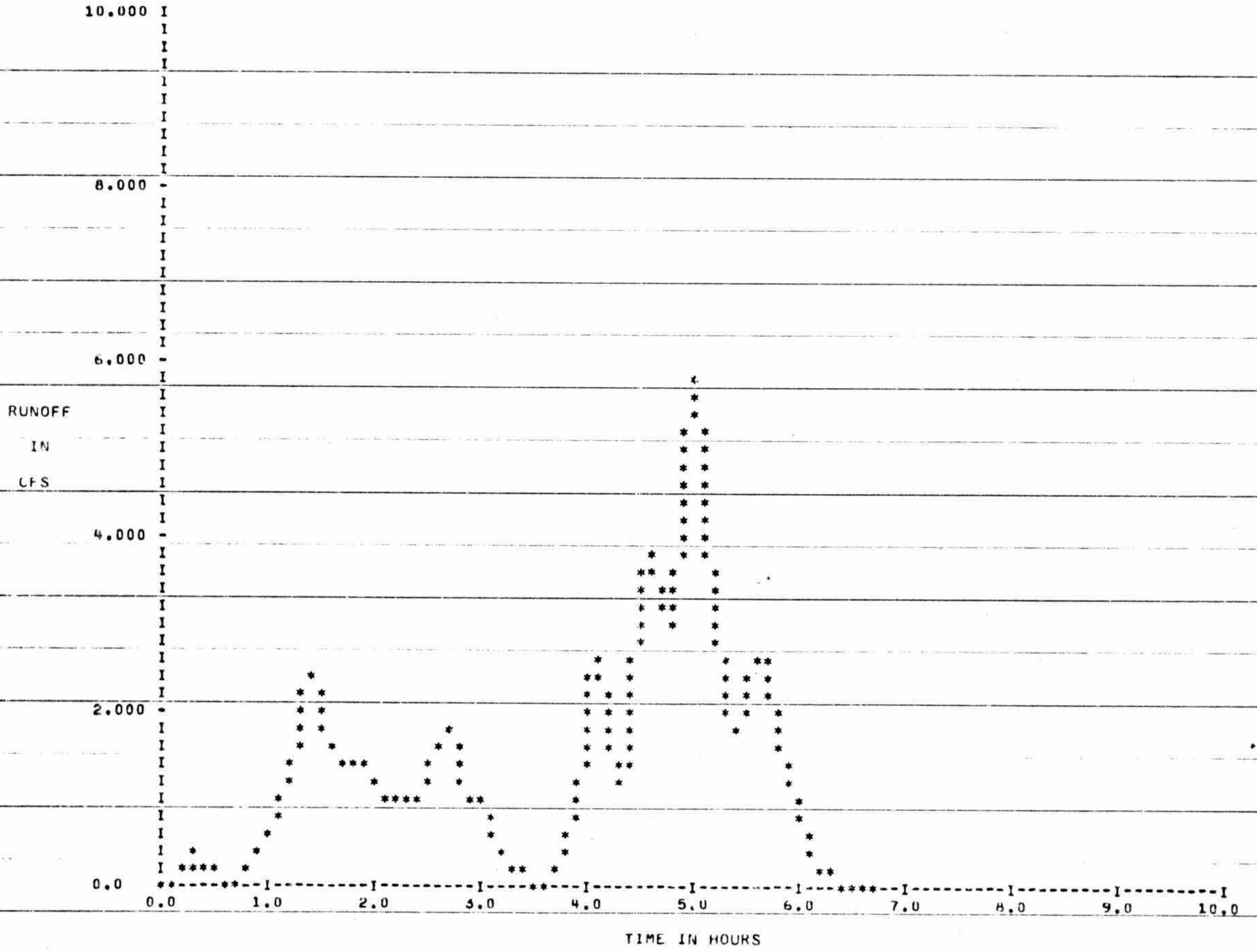
TOTAL SURFACE STORAGE AT END OF STORM (CU FT)0.395809E 04

TOTAL SNOWMELT (CU FT)                          0.0

ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL,     -0.00217
```


RAINFALL HYLTOGRAPH
BASIN NO 1
0.500
0.400
0.300
0.200
0.100
0.0
RAINFALL
IN
IN / HR
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
TIME IN HOURS
RAINGAGE LEGEND 1 = *

INLET HYDROGRAPH BASIN NO 1



DETAILED MODEL

THIS IS A SUMMARY OF THE QUANTITY AND QUALITY RESULTS

```
BRUCEWOOD QUANTITY AND QUALITY SIMULATION -  SWMM WORKSHOP
    STORM OF AUGUST 29,1975 --F  NED  &R & I &  &N

NSTEP  NPTS  NQS  DELT       TZERO       TAREA \

  80      5   10   300.        0.0        48.2

THE FOLLOWING INLET/GUTTER NUMBERS WILL BE PRINTED FOR SELECTED TIME STEPS

    47  160   21   30   40



*****  NOTE:  ONLY THE FIRST THREE POLLUTANTS ARE TRANSFERED TO OTHER BLOCKS.
```

```
          BRUCEWOOD QUANTITY AND QUALITY SIMULATION -  SWMM WORKSHOP
              STORM OF AUGUST 29,1975 --F  NED  &R & I &  &N

          SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION  47

          FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

     TIME    FLOW       BOD        SUS-S      COLIF       COD        SET-S      NIT       PO4         GREASE      PB         CL

   0  5.0   0.308E-0   81.4       191.       0.186E 07   230.       0.815      8.75      0.876       0.287       0.233E-02  0.0
   0 10.0   0.450E-0   55.6       114.       0.132E 07   160.       0.577      5.22      0.523       0.203       0.165E-02  0.0
   0 15.0   0.191E-0   39.3       64.4       0.999E 06   116.       0.436      2.98      0.298       0.154       0.125E-02  0.0
   0 20.0   0.705E-0   32.0       45.9       0.908E 06   95.6       0.397      2.14      0.214       0.140       0.114E-02  0.0
   0 25.0   0.315E-0   27.3       45.3       0.827E 06   80.7       0.362      2.10      0.210       0.127       0.104E-02  0.0
   0 30.0   0.150E-0   11.3       19.1       0.349E 06   33.5       0.153      0.887     0.888E-01   0.536E-01   0.437E-03  0.0
   0 35.0   0.842E-0   0.0        0.0        0.0         0.0        0.0        0.0       0.0         0.0         0.0        0.0
   0 40.0   0.956E-0   0.0        0.0        0.0         0.0        0.0        0.0       0.0         0.0         0.0        0.0
   0 45.0   0.199E-0   18.6       11.1       0.500E 06   57.8       0.218      0.538     0.540E-01   0.769E-01   0.626E-03  0.0
   0 50.0   0.223E-0   26.9       16.1       0.727E 06   83.7       0.317      0.780     0.782E-01   0.112       0.910E-03  0.0
   0 55.0   0.408E-0   30.0       28.0       0.823E 06   91.8       0.360      1.33      0.133       0.127       0.103E-02  0.0
   1  0.0   0.660E-0   33.4       54.7       0.927E 06   98.6       0.409      2.53      0.253       0.143       0.116E-02  0.0
   1  5.0   0.121      37.2       121.       0.995E 06   100.       0.449      5.52      0.552       0.153       0.125E-02  0.0
   1 10.0   0.124      37.9       152.       0.103E 07   97.7       0.471      6.93      0.694       0.158       0.129E-02  0.0
   1 15.0   0.160      37.6       184.       0.103E 07   91.7       0.485      8.38      0.838       0.159       0.129E-02  0.0
   1 20.0   0.205      38.1       241.       0.102E 07   84.4       0.495      10.9      1.09        0.156       0.127E-02  0.0
   1 25.0   0.133      36.3       239.       0.102E 07   79.4       0.508      10.8      1.08        0.158       0.128E-02  0.0
   1 30.0   0.102      31.1       164.       0.104E 07   74.8       0.511      7.48      0.748       0.160       0.130E-02  0.0
   1 35.0   0.101      27.7       127.       0.101E 07   70.1       0.488      5.78      0.578       0.155       0.126E-02  0.0
   1 40.0   0.993E-0   25.5       106.       0.989E 06   66.3       0.477      4.84      0.484       0.152       0.124E-02  0.0
   1 45.0   0.101      24.2       101.       0.984E 06   63.2       0.477      4.61      0.461       0.151       0.123E-02  0.0
   1 50.0   0.100      23.2       98.3       0.976E 06   60.3       0.477      4.50      0.450       0.150       0.122E-02  0.0
   1 55.0   0.101      22.1       95.6       0.969E 06   57.5       0.477      4.38      0.438       0.149       0.121E-02  0.0
   2  0.0   0.607E-0   21.1       85.4       0.975E 06   55.9       0.483      3.92      0.392       0.150       0.122E-02  0.0
   2  5.0   0.539E-0   19.4       61.5       0.979E 06   54.3       0.485      2.85      0.285       0.151       0.123E-02  0.0
   2 10.0   0.898E-0   18.7       67.0       0.941E 06   51.0       0.466      3.09      0.309       0.145       0.118E-02  0.0
   2 15.0   0.574E-0   18.3       66.7       0.940E 06   49.8       0.468      3.08      0.308       0.145       0.118E-02  0.0
   2 20.0   0.539E-0   17.2       49.9       0.956E 06   49.1       0.479      2.32      0.232       0.147       0.120E-02  0.0
   2 25.0   0.897E-0   16.9       60.7       0.927E 06   46.4       0.465      2.80      0.281       0.143       0.116E-02  0.0
   2 30.0   0.970E-0   16.8       71.3       0.918E 06   44.5       0.465      3.28      0.328       0.141       0.115E-02  0.0
   2 35.0   0.164      18.1       115.       0.911E 06   41.9       0.476      5.22      0.523       0.140       0.114E-02  0.0
   2 40.0   0.145      18.3       129.       0.912E 06   40.1       0.486      5.88      0.588       0.140       0.114E-02  0.0
   2 45.0   0.408E-0   17.9       122.       0.945E 06   40.1       0.514      5.58      0.558       0.145       0.118E-02  0.0
   2 50.0   0.620E-0   16.0       88.4       0.953E 06   39.4       0.518      4.06      0.406       0.147       0.119E-02  0.0
   2 55.0   0.947E-0   13.6       66.9       0.886E 06   35.1       0.468      3.08      0.308       0.136       0.111E-02  0.0
   3  0.0   0.528E-0   13.1       61.1       0.890E 06   34.6       0.471      2.82      0.282       0.137       0.112E-02  0.0
   3  5.0   0.145E-0   13.2       51.2       0.945E 06   36.5       0.511      2.38      0.238       0.145       0.118E-02  0.0
   3 10.0   0.524E-0   14.5       62.2       0.998E 06   38.9       0.554      2.88      0.288       0.154       0.125E-02  0.0
   3 15.0   0.208E-0   13.1       53.9       0.915E 06   35.6       0.509      2.50      0.250       0.141       0.115E-02  0.0
   3 20.0   0.108E-0   5.69       23.2       0.398E 06   15.5       0.222      1.07      0.108       0.613E-01   0.499E-03  0.0
   3 25.0   0.652E-0   0.0        0.0        0.0         0.0        0.0        0.0       0.0         0.0         0.0        0.0
   3 30.0   0.434E-0   0.0        0.0        0.0         0.0        0.0        0.0       0.0         0.0         0.0        0.0
   3 35.0   0.312E-0   0.0        0.0        0.0         0.0        0.0        0.0       0.0         0.0         0.0        0.0
   3 40.0   0.412E-0   8.77       18.4       0.741E 06   27.1       0.379      0.885     0.887E-01   0.114       0.928E-03  0.0
   3 45.0   0.847E-0   9.94       34.7       0.789E 06   28.4       0.412      1.62      0.163       0.121       0.989E-03  0.0
   3 50.0   0.543E-0   10.3       36.5       0.826E 06   29.4       0.438      1.71      0.171       0.127       0.103E-02  0.0
   3 55.0   0.117      10.8       47.1       0.856E 06   29.5       0.464      2.19      0.219       0.132       0.107E-02  0.0
   4  0.0   0.258      13.4       113.       0.843E 06   27.1       0.497      5.14      0.514       0.130       0.106E-02  0.0
```

RUNOFF BLOCK WORKSHOP EXAMPLE NO. 1

Assumptions:
1) Each house has a 15' wide paved driveway.
2) All roof leaders are connected.
3) 2-year design storm.

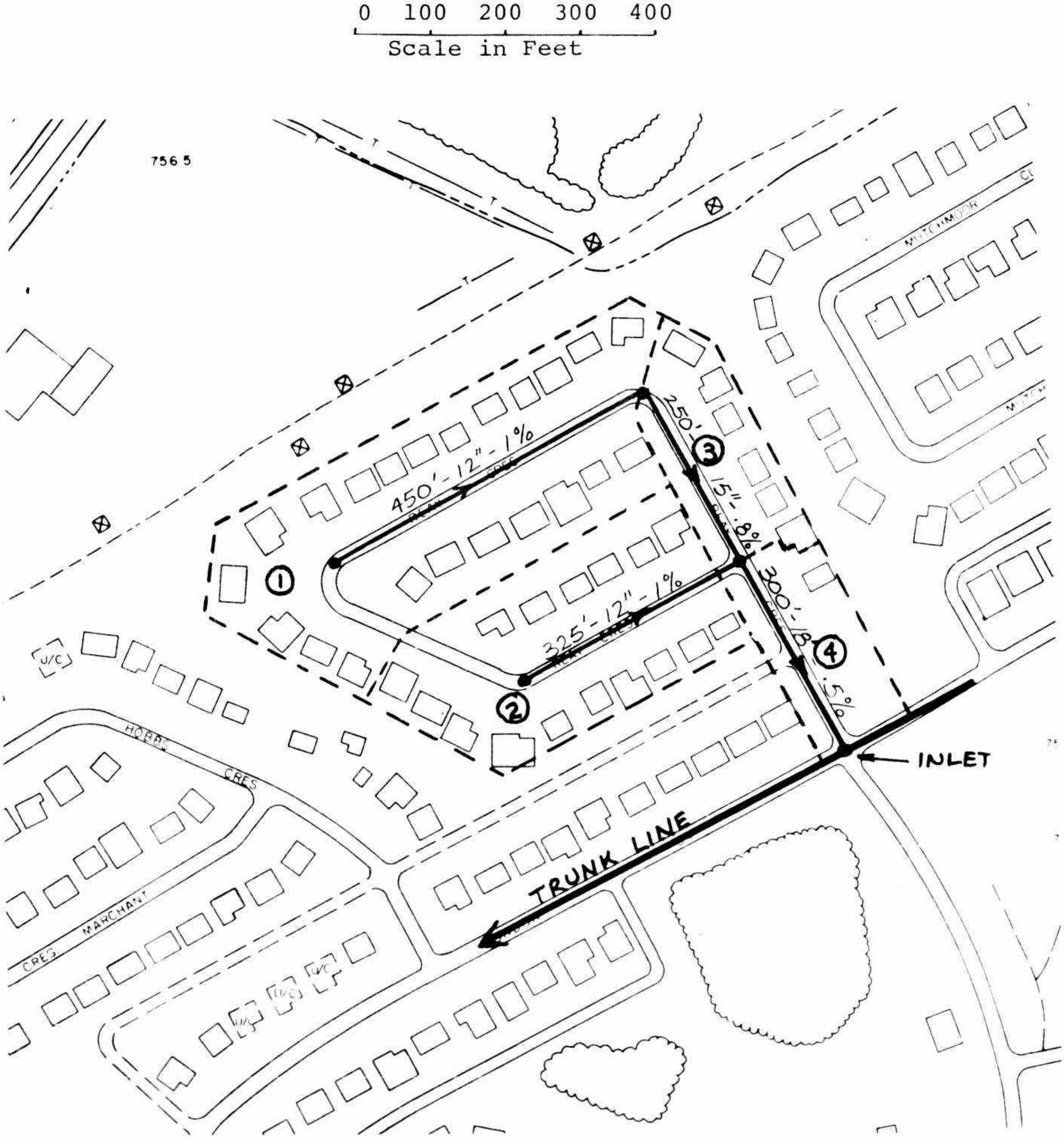
Total Drainage Area = 6.61 acres.

Prepare input data and fill out coding form for each subcatchment and gutter/pipe (card groups 5 and 7 only).

Example No. 1

Assume each house to have a 15' wide paved driveway.

All areas except roads, roofs, and driveways are pervious.



JAMES F. MacLAREN LTD.

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SWMM WORKSHOP

EXAMPLE #1

SUBMITTED BY

JOB NUMBER 10680

PAGE NO. 1/2

CARD GROUP	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-65	66-70	71-75	76-80
1	SWMM WØRKSHØP - RUNOFF BLOCK															
	EXAMPLE NO. 1 - 2YR DESIGN, STØRM LEADERS CONNECTED															
2	1	4.0	0 0	5.	1	25.	1	1.08	1							
3	2.0	5.														
4	.12	.14	.16	.18	.22	.29	.42	.91	2.86	1.16						
	.67	.48	.37	.31	.27	.24	.21	.19	.18	0.0						
4A		0		3.0		1.0		0.5								
4B	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
	40	40	40	40	40	40	40	40								
5		100	300	2		1.	450.		.01					.013		
		200	400	2		1.	325.		.01					.013		
		300	400	2	1	.25	250.		.008					.013		
		400	10	2	1	.50	300.		.005					.013		
6																
7	1	1	100	1021.	2.93	42.4	.03	.013	.25	.062	.184	3.0	.52		.00115	
	1	2	200	752.	1.90	51.1	.03	.013	.25	.062	.184	3.0	.52		.00115	
	1	3	300	529.	.85	34.1	.03	.013	.25	.062	.184	3.0	.52		.00115	
	1	4	400	579.	.93	20.4	.03	.013	.25	.062	.184	3.0	.52		.00115	
8																
8A	1	25.	.25	65.	.60	2.0	2.0	2.0	.013	.25						
	2	30.	.25	70.	.60	2.0	2.0	2.0	.013	.25						
	3	20.	.25	60.	.60	2.0	2.0	2.0	.013	.25						
	4	25.	.25	65.	.60	2.0	2.0	2.0	.013	.25						
9		1		15		7		1		20		100.	0	2		
9A		0.7		2.3		3.3		4.6		1.5						
9B		10														

JAMES F. MacLAREN LTD.

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SUBMITTED BY

JOB NUMBER 10680

PAGE NO. 2/2

	1 2 3 4 5	6 7 8 9 10	11 12 13 14 15	16 17 18 19 20	21 22 23 24 25	26 27 28 29 30	31 32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48 49 50	51 52 53 54 55
9c		100.		100.		100.		100.		100.	SET-S
		1000.		1000		1000.		1000.		1000.	SUS-S
	.1	3E 7	.2	7E 7	.1	7E 7	.	1E 7		0	COLIF
		5.		3.6		7.7		3.12		5.0	BOD
		40.		40.		40.		40.		20.	COD
		.48		.61		.41		.43		.05	NIT
		.05		.05		.07		.03		.03	PO4.
		1.		1.		1.		1.		1.	GREASE
											LEAD
											CL
10	1	0									
	2	0									
	3	0									
	4	.78	110.	0.2	1.	1.20					
11		1	1		4.		4.50		66.		.0057
		2	1		2.		3.25		43.		.0057
		3	1		2.		2.50		33.		.0057
		4	1		4.		3.00		40.		.0057
12	4	1									
13	100	200	300	400							

```
          SWMM WORKSHOP - RUNOFF BLOCK

          EXAMPLE NO 1 - 2YR DESIGN STORM, ROOF LEADERS CONNECTED



 BASIN NUMBER    1

 NUMBER OF TIME STEPS   40

 INTEGRATION TIME INTERVAL (MINUTES),    5.00

 25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

 EROSION FOR SUBCATCHMENTS IS TO BE MODELED.
 HIGHEST 30 MIN. RAIN INTENSITY IS  1.08 IN/HR

 FOR  20 RAINFALL STEPS, THE TIME INTERVAL IS   5.00 MINUTES


 FOR RAINGAGE NUMBER  1,  RAINFALL HISTORY IS

      0.12      0.14      0.16      0.18      0.22      0.29      0.42      0.91      2.86      1.16
      0.67      0.48      0.37      0.31      0.27      0.24      0.21      0.19      0.18      0.0

   DEGREE HOUR MELT RATE =   0.0

  TEMPERATURE OF SNOW BASE =      30.0

  WIND FACTOR =         0.00500

  GAMMA FACTOR =         0.07913

  TEMPERATURE AT EACH TIME STEP
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
```

```
* * * * *  G U T T E R   A N D   P I P E   D A T A  * * * * *

GUTTER       GUTTER         WIDTH     LENGTH      SLOPE    SIDE SLOPES     MANNING      OVERFLOW
NUMBER     CONNECTION        (FT)       (FT)     (FT/FT)     L      R         N            (IN)

  1   * 100    300            1.0       450.      0.010     0.0    0.0      0.013         10.00
  2   * 200    400            1.0       325.      0.010     0.0    0.0      0.013         10.00
  3   * 300    400            1.5       250.      0.008     0.0    0.0      0.013         10.00
  4   * 400     10            1.5       300.      0.005     0.0    0.0      0.013         10.00

TOTAL NUMBER OF GUTTERS/PIPES,    4

ASTERISK (*) DENOTES CIRCULAR PIPE, DIAMETER=.WIDTH.
```

```
* * * * *  S U B C A T C H M E N T   D A T A  * * * * *

SUBCATCH-  GUTTER     WIDTH    AREA   PERCENT    SLOPE     RESISTANCE FACTOR   SURFACE STORAGE(IN)      INFILTRATION      DECAY RATE  GAGE
MENT NO.  OR INLET    (FT)     (AC)   IMPERV.   (FT/FT)    IMPERV.      PERV.   IMPERV.       PERV.     RATE(IN/HR)         (1/SEC)    NO.
                                                                                                    MAXIMUM MINIMUM
   1    1    100     1021.0     2.9    42.4     0.030      0.013      0.250     0.062       0.184    3.00      0.52      0.00115      1
   2    2    200      752.0     1.9    51.1     0.030      0.013      0.250     0.062       0.184    3.00      0.52      0.00115      1
   3    3    300      529.0     0.8    34.1     0.030      0.013      0.250     0.062       0.184    3.00      0.52      0.00115      1
   4    4    400      579.0     0.9    20.4     0.030      0.013      0.250     0.062       0.184    3.00      0.52      0.00115      1

TOTAL NUMBER OF SUBCATCHMENTS,    4

TOTAL TRIBUTARY AREA (ACRES),    6.61
```

```
          *** SNOW DATA ***

SUBCATCH-  PERCENT    W.E.       PERCENT    W.E.       PERCENT INITAL F.W.   PERCENT    RESISTANCE FACTOR
MENT NO.   IMPERV.    (IN)       PERVIOUS   (IN)        IMPERV.     PERV.    F.W.H.C.   IMPERV.     PERV.

     1        25.0     0.250       65.0      0.600        2.00       2.00       2.00     0.130E-01  0.250
     2        30.0     0.250       70.0      0.600        2.00       2.00       2.00     0.130E-01  0.250
     3        20.0     0.250       60.0      0.600        2.00       2.00       2.00     0.130E-01  0.250
     4        25.0     0.250       65.0      0.600        2.00       2.00       2.00     0.130E-01  0.250
```

```
ARRANGEMENT OF SUBCATCHMENTS AND GUTTERS/PIPES

     GUTTER     TRIBUTARY GUTTER/PIPE                                   TRIBUTARY SUBAREA
     OR PIPE

     100                                                                1

     200                                                                2

     300       100                                                      3

     400       200   300                                                4

     INLET      TRIBUTARY GUTTERS AND/OR PIPES                     TRIBUTARY SUBAREAS

      10        400
```

```
HYDROGRAPHS WILL BE STORED FOR THE FOLLOWING   1 INLETS     .
           10
```

```
                 QUALITY DEFAULT PARAMETER CHANGES

                 NQS= 10

DDFACT           0.70000        2.3000         3.3000         4.6000         1.5000

SET-S             100.00         100.00         100.00         100.00         100.00
SUS-S             1000.0         1000.0         1000.0         1000.0         1000.0
COLIF            0.65000E 07    0.27000E 07    0.17000E 07    0.10000E 07    0.0
BOD               5.0000         3.6000         7.7000         3.1200         5.0000
COD               40.000         40.000         39.000         40.000         20.000
NIT              0.48000        0.61000        0.41000        0.43000        0.50000E-01
PO4              0.50000E-01    0.50000E-01    0.70000E-01    0.30000E-01    0.30000E-01
GREASE            1.0000         1.0000         1.0000         1.0000         1.0000
PB               0.0            0.0            0.0            0.0            0.0
CL               0.0            0.0            0.0            0.0            0.0



     .....QUALITY SIMULATION INCLUDED IN THIS RUN.....


     INPUT PARAMETERS AS FOLLOWS


     NUMBER OF CONSTITUENTS       10

     NUMBER OF DRY DAYS         15.0

     STREET CLEANING FREQ        7.0 DAYS

     PASSES PER CLEANING           1

     STD CATCHBASIN VOLUME     20.00 FT3

     CATCHBASIN CONTENTS BOD   100.0 MG/L

     METHOD FOR CALCULATING SS:
       SAME AS FOR ALL OTHER
       POLLUTANTS (VOL. I).
       ISS = 0
```

```
WATERSHED QUALITY DEFINITIONS

SUBAREA     LAND USE    TOTAL   GUTTER        NUMBER  OF
 NUMBER      CLASS.    LENGTH*10**2 FT.    CATCHBASINS

  1      1      1          4.50               4.00
  2      2      1          3.25               2.00
  3      3      1          2.50               2.00
  4      4      1          3.00               4.00
```

```
HYDROGRAPHS WILL BE LISTED FOR THE FOLLOWING   4 GUTTERS OR INLETS

          100  200  300  400


TOTAL RAINFALL (CU FT)                             0.187550E 05
TOTAL INFILTRATION (CU FT)                         0.131548E 05
TOTAL GUTTER FLOW AT INLET (CU FT)                 0.875951E 04
TOTAL SURFACE STORAGE AT END OF STORM (CU FT)0.494510E 03
TOTAL SNOWMELT (CU FT)                             0.365445E 04
ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL,          0.00287
```

```
* * * * *   S U M M A R Y   O F   F I N A L   S N O W   C O N D I T I O N S   * * * * *

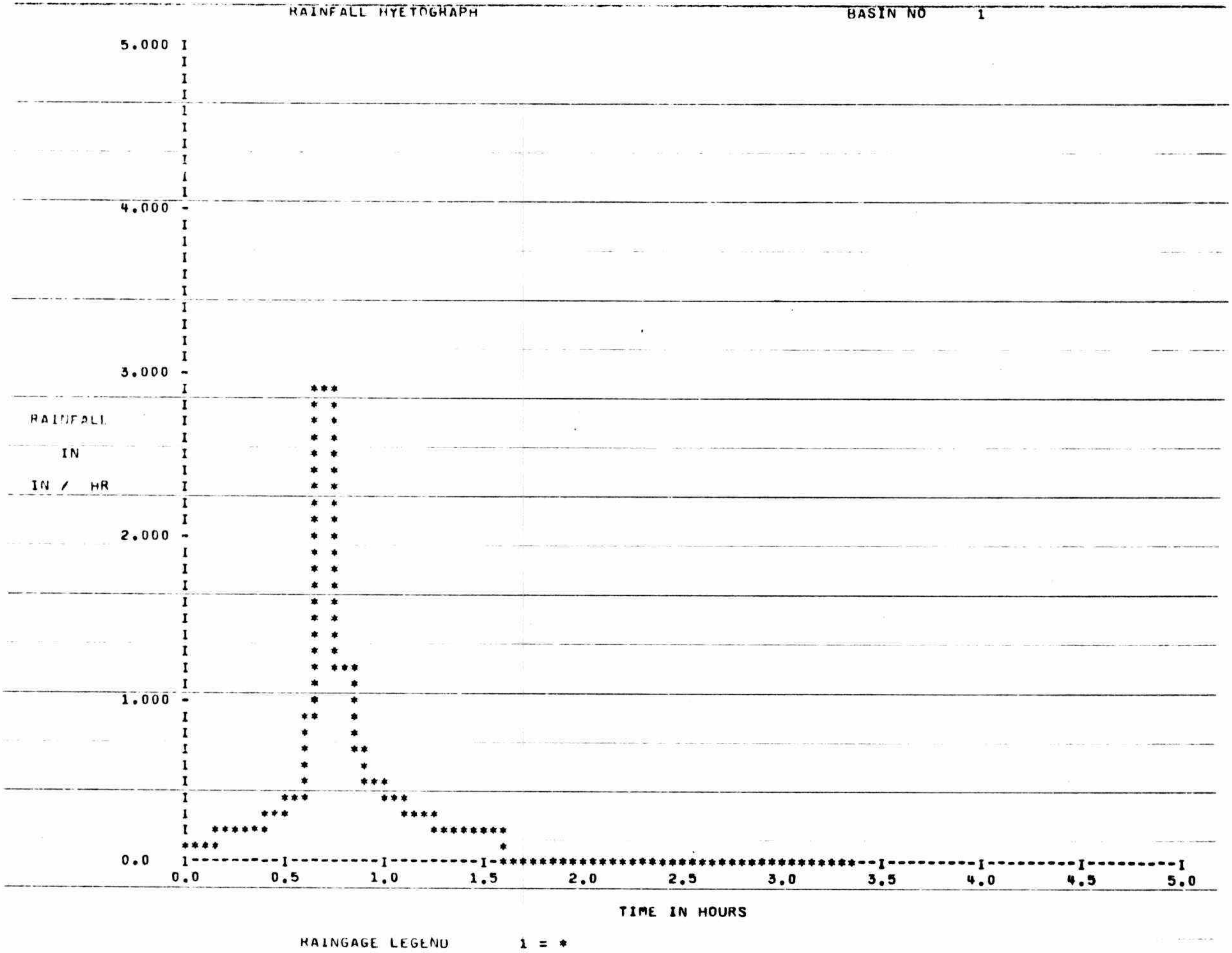
WATERSHED   SNOW COVERED AREA (SQFT)        DEPTH OF SNOW (FT)             FREE WATER (FT)
              IMPERV          PERV        IMPERV          PERV         IMPERV          PERV

    1         13529.         47785.       0.0            0.02367       0.00000        0.00047

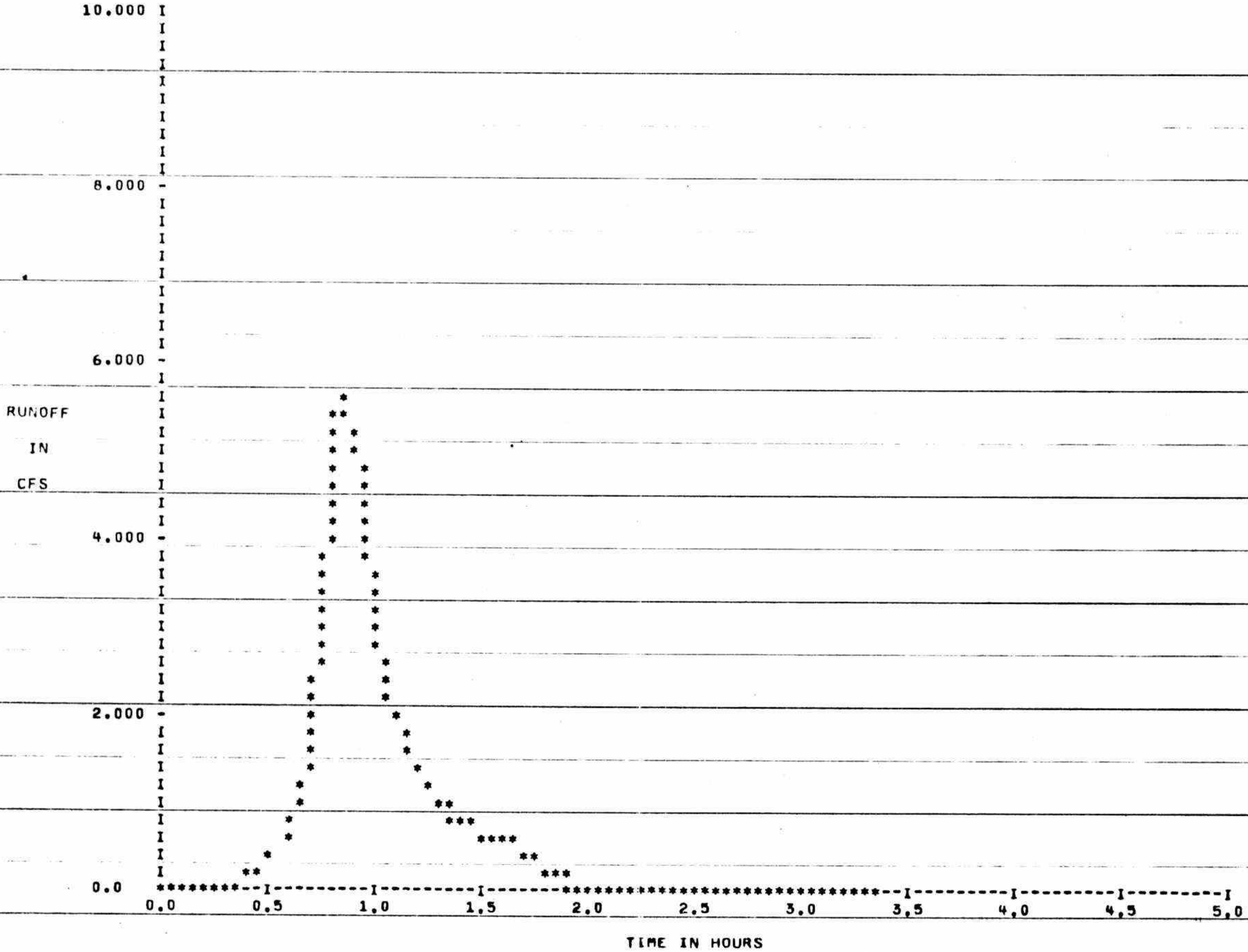
    2         12688.         28330.       0.0            0.02367       0.00000        0.00047

    3          2525.         14640.       0.0            0.02367       0.00000        0.00047

    4          2066.         20960.       0.0            0.02367       0.00000        0.00047
```


RAINFALL HYETOGRAPH
BASIN NO 1
5.000
4.000
3.000
2.000
1.000
0.0
RAINFALL
IN
IN / HR
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
TIME IN HOURS
RAINGAGE LEGEND 1 = *

INLET HYDROGRAPH BASIN NO 1



```
THIS IS A SUMMARY OF THE QUANTITY AND QUALITY RESULTS

SWMM WORKSHOP - RUNOFF BLOCK
EXAMPLE NO 1 - 2YR DESIGN STORM, ROOF LEADERS CONNECTED

NSTEP  NPTS  NQS  DELT       TZERO      TAREA

  40     4   11   300.        0.0        6.6

THE FOLLOWING INLET/GUTTER NUMBERS WILL BE PRINTED FOR SELECTED TIME STEPS

  100  200  300  400


*****  NOTE:  ONLY THE FIRST THREE POLLUTANTS ARE TRANSFERED TO OTHER BLOCKS.
```

```
SWMM WORKSHOP - RUNOFF BLOCK
EXAMPLE NO 1 - 2YR DESIGN STORM, ROOF LEADERS CONNECTED

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 100

FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

 TIME     FLOW       BOD          SUS-S       COLIF       COD        SET-S      NIT        PO4         GREASE      PB           CL
                     SUS-SNE
0  5.0   0.718E-0   0.0          0.0         0.0         0.0        0.0        0.0        0.0         0.0         0.0          0.0
                     0.0
0 10.0   0.254E-0   44.2         9.45        0.951E 06   139.       0.413      0.500      0.502E-01   0.146       0.195E-02    200.
                     9.45
0 15.0   0.356E-0   53.5         12.2        0.119E 07   168.       0.519      0.640      0.644E-01   0.183       0.243E-02    250.
                     12.2
0 20.0   0.521E-0   53.1         13.7        0.126E 07   167.       0.556      0.714      0.718E-01   0.194       0.258E-02    265.
                     13.7
0 25.0   0.119      46.3         17.3        0.127E 07   146.       0.597      0.879      0.883E-01   0.196       0.260E-02    268.
                     17.3
0 30.0   0.242      34.8         25.0        0.125E 07   109.       0.710       1.22      0.123       0.193       0.256E-02    264.
                     25.0
.0 35.0  0.425      21.4         37.3        0.121E 07   65.0       0.992       1.78      0.178       0.186       0.248E-02    255.
                     37.3
0 40.0   0.782      10.7         61.6        0.113E 07   27.7        1.88       2.87      0.288       0.174       0.231E-02    238.
                     61.6
0 45.0    2.15      9.04         145.        0.954E 06   8.66        8.43       6.67      0.667       0.147       0.195E-02    201.
                     145.
0 50.0    2.83      7.73         137.        0.748E 06   4.72        12.4       6.36      0.636       0.115       0.153E-02    158.
                     137.
0 55.0    1.74      5.24         92.8        0.553E 06   3.37        9.48       4.31      0.431       0.851E-01   0.113E-02    116.
                     92.8
1  0.0    1.09      2.75         48.1        0.418E 06   2.59       0.756       2.20      0.220       0.643E-01   0.855E-03    88.0
                     48.1
1  5.0   0.874      2.02         33.8        0.380E 06   2.34        1.95       1.57      0.157       0.585E-01   0.778E-03    80.0
                     33.8
1 10.0   0.596      1.57         25.8        0.340E 06   2.09        1.05       1.20      0.120       0.523E-01   0.696E-03    71.6
                     25.8
1 15.0   0.477      1.18         18.4        0.314E 06   1.93       0.730      0.858      0.859E-01   0.482E-01   0.641E-03    66.0
                     18.4
1 20.0   0.379      1.02         15.6        0.296E 06   1.82       0.602      0.730      0.731E-01   0.456E-01   0.606E-03    62.4
                     15.6
1 25.0   0.326     0.887         13.2        0.281E 06   1.73       0.506      0.620      0.621E-01   0.433E-01   0.576E-03    59.3
                     13.2
1 30.0   0.288     0.811         11.9        0.270E 06   1.66       0.459      0.559      0.560E-01   0.415E-01   0.552E-03    56.9
                     11.9
1 35.0   0.266     0.756         11.0        0.260E 06   1.60       0.429      0.516      0.517E-01   0.400E-01   0.532E-03    54.8
                     11.0
1 40.0   0.186     0.692         9.79        0.252E 06   1.55       0.395      0.463      0.464E-01   0.388E-01   0.516E-03    53.1
                     9.79
1 45.0   0.719E-0  0.592         7.91        0.247E 06   1.52       0.348      0.377      0.378E-01   0.380E-01   0.505E-03    52.0
                     7.91
1 50.0   0.301E-0  0.490         5.92        0.244E 06   1.50       0.310      0.288      0.288E-01   0.375E-01   0.498E-03    51.3
                     5.92
1 55.0   0.293E-0  0.445         5.05        0.242E 06   1.49       0.298      0.248      0.249E-01   0.373E-01   0.495E-03    51.0
                     5.05
2  0.0   0.275E-0  0.426         4.69        0.241E 06   1.48       0.293      0.232      0.232E-01   0.371E-01   0.493E-03    50.7
                     4.69
```

```
2  5.0   0.271E-0  0.417      4.53    0.240E 06   1.48    0.291    0.225    0.225E-01  0.369E-01  0.491E-03   50.5
                     4.53
2 10.0   0.268E-0  0.413      4.47    0.239E 06   1.47    0.290    0.222    0.222E-01  0.368E-01  0.489E-03   50.3
                     4.47
2 15.0   0.266E-0  0.411      4.44    0.238E 06   1.47    0.290    0.220    0.221E-01  0.367E-01  0.487E-03   50.2
                     4.44
2 20.0   0.265E-0  0.410      4.42    0.237E 06   1.46    0.290    0.220    0.220E-01  0.365E-01  0.486E-03   50.0
                     4.42
2 25.0   0.264E-0  0.409      4.42    0.237E 06   1.46    0.290    0.219    0.220E-01  0.364E-01  0.484E-03   49.8
                     4.42
2 30.0   0.263E-0  0.408      4.41    0.236E 06   1.45    0.290    0.219    0.220E-01  0.363E-01  0.482E-03   49.6
                     4.41
2 35.0   0.209E-0  0.406      4.38    0.235E 06   1.45    0.290    0.217    0.218E-01  0.362E-01  0.481E-03   49.5
                     4.38
2 40.0   0.966E-0  0.401      4.29    0.234E 06   1.44    0.289    0.213    0.214E-01  0.360E-01  0.479E-03   49.3
                     4.29
2 45.0   0.245E-0  0.395      4.20    0.233E 06   1.44    0.288    0.209    0.210E-01  0.359E-01  0.477E-03   49.1
                     4.20
2 50.0   0.779E-0  0.197      2.08    0.117E 06  0.718    0.144    0.104    0.104E-01  0.180E-01  0.239E-03   24.6
                     2.08
2 55.0   0.418E-0  0.0       0.0      0.0        0.0      0.0      0.0      0.0        0.0        0.0         0.0
                   0.0
3  0.0   0.269E-0  0.0       0.0      0.0        0.0      0.0      0.0      0.0        0.0        0.0         0.0
                   0.0
3  5.0   0.191E-0  0.0       0.0      0.0        0.0      0.0      0.0      0.0        0.0        0.0         0.0
                   0.0
3 10.0   0.145E-0  0.0       0.0      0.0        0.0      0.0      0.0      0.0        0.0        0.0         0.0
                   0.0
3 15.0   0.115E-0  0.0       0.0      0.0        0.0      0.0      0.0      0.0        0.0        0.0         0.0
                   0.0
3 20.0   0.937E-0  0.0       0.0      0.0        0.0      0.0      0.0      0.0        0.0        0.0         0.0
                   0.0
```

```
SWMM WORKSHOP - RUNOFF BLOCK
EXAMPLE NO 1 - 2YR DESIGN STORM, ROOF LEADERS CONNECTED

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 200

FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

   TIME     FLOW        BOD        SUS-S      COLIF       COD        SET-S      NIT       PO4        GREASE     PB           CL
                        SUS-SNE
 0  5.0    0.525E-0   0.0         0.0       0.0        0.0        0.0        0.0        0.0        0.0        0.0          0.0
                      0.0
 0 10.0    0.185E-0   43.5        10.8      0.107E 07  137.       0.466      0.570      0.573E-01  0.165      0.219E-02   203.
                      10.8
 0 15.0    0.259E-0   51.9        14.0      0.134E 07  164.       0.587      0.735      0.739E-01  0.206      0.274E-02   255.
                      14.0
 0 20.0    0.397E-0   49.3        15.9      0.141E 07  156.       0.629      0.828      0.833E-01  0.218      0.289E-02   268.
                      15.9
 0 25.0    0.989E-0   38.6        21.8      0.141E 07  122.       0.696       1.09      0.110      0.218      0.289E-02   269.
                      21.8
 0 30.0    0.200      24.7        33.1      0.138E 07  76.6       0.896       1.60      0.161      0.213      0.283E-02   263.
                      33.1
 0 35.0    0.338      12.5        50.0      0.132E 07  35.9        1.36       2.36      0.237      0.203      0.270E-02   251.
                      50.0
 0 40.0    0.616      6.90        83.2      0.121E 07  12.9        2.79       3.86      0.386      0.187      0.248E-02   230.
                      83.2
 0 45.0     1.68      9.11        160.      0.983E 06  6.28        13.0       7.42      0.742      0.151      0.201E-02   187.
                      160.
 0 50.0     2.21      7.72        138.      0.725E 06  4.45        14.3       6.39      0.640      0.112      0.148E-02   138.
                      138.
 0 55.0     1.33      5.00        89.0      0.490E 06  3.02        8.55       4.13      0.413      0.754E-01  0.100E-02   93.0
                      89.0
 1  0.0    0.806      2.89        52.0      0.362E 06  2.22       0.761       2.37      0.238      0.557E-01  0.740E-03   68.7
                      52.0
 1  5.0    0.641      1.79        29.8      0.331E 06  2.04        2.13       1.39      0.139      0.509E-01  0.677E-03   62.9
                      29.8
 1 10.0    0.440      1.46        24.4      0.287E 06  1.77       0.859       1.13      0.113      0.442E-01  0.588E-03   54.6
                      24.4
 1 15.0    0.361      1.05        16.6      0.265E 06  1.63       0.726      0.774      0.774E-01  0.407E-01  0.541E-03   50.2
                      16.6
 1 20.0    0.292      0.941       14.8      0.248E 06  1.52       0.573      0.689      0.690E-01  0.381E-01  0.507E-03   47.0
                      14.8
 1 25.0    0.257      0.811       12.4      0.233E 06  1.44       0.482      0.582      0.583E-01  0.359E-01  0.477E-03   44.3
                      12.4
 1 30.0    0.229      0.747       11.4      0.222E 06  1.37       0.439      0.532      0.533E-01  0.342E-01  0.454E-03   42.2
                      11.4
 1 35.0    0.212      0.694       10.5      0.212E 06  1.30       0.407      0.491      0.491E-01  0.326E-01  0.434E-03   40.3
                      10.5
 1 40.0    0.150      0.624       9.18      0.204E 06  1.26       0.364      0.432      0.433E-01  0.314E-01  0.418E-03   38.8
                      9.18
 1 45.0    0.602E-0   0.508       6.97      0.199E 06  1.22       0.300      0.331      0.332E-01  0.306E-01  0.407E-03   37.8
                      6.97
 1 50.0    0.270E-0   0.389       4.67      0.196E 06  1.21       0.252      0.227      0.228E-01  0.301E-01  0.401E-03   37.2
                      4.67
 1 55.0    0.267E-0   0.359       4.08      0.194E 06  1.20       0.245      0.200      0.201E-01  0.299E-01  0.398E-03   36.9
                      4.08
 2  0.0    0.255E-0   0.351       3.95      0.193E 06  1.19       0.244      0.195      0.195E-01  0.298E-01  0.396E-03   36.7
                      3.95
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2  5.0   0.252E-0  0.348     3.90    0.192E 06   1.18    0.243    0.192       0.193E-01  0.296E-01  0.393E-03  36.5
                   3.90
2 10.0   0.250E-0  0.346     3.88    0.191E 06   1.18    0.243    0.191       0.192E-01  0.294E-01  0.391E-03  36.3
                   3.88
2 15.0   0.248E-0  0.345     3.87    0.190E 06   1.17    0.243    0.191       0.191E-01  0.293E-01  0.389E-03  36.2
                   3.87
2 20.0   0.247E-0  0.344     3.87    0.189E 06   1.17    0.243    0.190       0.191E-01  0.291E-01  0.387E-03  36.0
                   3.87
2 25.0   0.247E-0  0.343     3.86    0.189E 06   1.16    0.243    0.190       0.191E-01  0.290E-01  0.386E-03  35.8
                   3.86
2 30.0   0.246E-0  0.342     3.86    0.188E 06   1.15    0.243    0.190       0.190E-01  0.289E-01  0.384E-03  35.6
                   3.86
2 35.0   0.198E-0  0.339     3.81    0.187E 06   1.15    0.242    0.188       0.188E-01  0.287E-01  0.382E-03  35.4
                   3.81
2 40.0   0.962E-0  0.331     3.68    0.185E 06   1.14    0.240    0.182       0.182E-01  0.285E-01  0.379E-03  35.2
                   3.68
2 45.0   0.272E-0  0.322     3.52    0.184E 06   1.13    0.238    0.174       0.175E-01  0.283E-01  0.376E-03  34.9
                   3.52
2 50.0   0.915E-0  0.160     1.73    0.920E 05   0.566   0.119    0.857E-01   0.860E-02  0.142E-01  0.188E-03  17.5
                   1.73
2 55.0   0.482E-0  0.0       0.0     0.0         0.0     0.0      0.0         0.0        0.0        0.0        0.0
                   0.0
3  0.0   0.302E-0  0.0       0.0     0.0         0.0     0.0      0.0         0.0        0.0        0.0        0.0
                   0.0
3  5.0   0.209E-0  0.0       0.0     0.0         0.0     0.0      0.0         0.0        0.0        0.0        0.0
                   0.0
3 10.0   0.154E-0  0.0       0.0     0.0         0.0     0.0      0.0         0.0        0.0        0.0        0.0
                   0.0
3 15.0   0.119E-0  0.0       0.0     0.0         0.0     0.0      0.0         0.0        0.0        0.0        0.0
                   0.0
3 20.0   0.952E-0  0.0       0.0     0.0         0.0     0.0      0.0         0.0        0.0        0.0        0.0
                   0.0
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        SWMM WORKSHOP - RUNOFF BLOCK
        EXAMPLE NO 1 - 2YR DESIGN STORM, ROOF LEADERS CONNECTED

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        SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 300


        FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

    ----TIME-----FLOW---------BOD------------SUS-S--------COLIF-------COD---------SET-S-------NIT--------PO4----------GREASE------PB------------CL---
                              SUS-SNE
     0  5.0     0.353E-0    0.0            0.0         0.0         0.0         0.0         0.0        0.0          0.0         0.0          0.0
                              0.0
     0 10.0     0.165E-0    41.7           12.6        0.127E 07   132.        0.553       0.666      0.670E-01    0.196       0.261E-02    251.
                              12.6
     0 15.0     0.327E-0    52.1           15.1        0.149E 07   165.        0.651       0.796      0.800E-01    0.230       0.306E-02    298.
                              15.1
     0 20.0     0.529E-0    54.3           16.4        0.154E 07   172.        0.678       0.857      0.861E-01    0.237       0.315E-02    311.
                              16.4
     0 25.0     0.108       50.2           19.8        0.156E 07   159.        0.717        1.02      0.102        0.240       0.319E-02    316.
                              19.8
     0 30.0     0.241       40.4           28.2        0.154E 07   127.        0.831        1.39      0.140        0.237       0.315E-02    312.
                              28.2
     0 35.0     0.454       27.8           41.4        0.148E 07   85.2         1.11        1.98      0.199        0.228       0.303E-02    301.
                              41.4
     0 40.0     0.842       15.6           67.1        0.138E 07   43.1         1.97        3.14      0.315        0.213       0.283E-02    281.
                              67.1
     0 45.0      2.23       11.5           162.        0.119E 07   14.5         8.73        7.46      0.747        0.183       0.244E-02    242.
                              162.
     0 50.0      3.43       9.65           168.        0.940E 06   6.53         13.3        7.78      0.778        0.145       0.192E-02    191.
                              168.
     0 55.0      2.58       6.67           120.        0.695E 06   4.06         11.4        5.55      0.555        0.107       0.142E-02    142.
                              120.
     1  0.0      1.49       3.40           57.8        0.523E 06   3.41         2.38        2.66      0.266        0.805E-01   0.107E-02    106.
                              57.8
     1  5.0      1.15       2.64           45.3        0.485E 06   2.88         1.46        2.09      0.209        0.746E-01   0.992E-03    98.4
                              45.3
     1 10.0     0.827       1.87           29.9        0.422E 06   2.65         1.89        1.39      0.140        0.649E-01   0.863E-03    86.1
                              29.9
     1 15.0     0.609       1.45           23.1        0.388E 06   2.36        0.557        1.07      0.107        0.597E-01   0.794E-03    79.1
                              23.1
     1 20.0     0.497       1.21           18.1        0.368E 06   2.28        0.842       0.849      0.850E-01    0.567E-01   0.753E-03    75.0
                              18.1
     1 25.0     0.416       1.08           16.0        0.351E 06   2.16        0.571       0.751      0.752E-01    0.540E-01   0.718E-03    71.5
                              16.0
     1 30.0     0.367       0.983          14.2        0.340E 06   2.09        0.570       0.669      0.670E-01    0.523E-01   0.696E-03    69.2
                              14.2
     1 35.0     0.334       0.922          13.2        0.329E 06   2.02        0.520       0.622      0.623E-01    0.506E-01   0.672E-03    66.8
                              13.2
     1 40.0     0.261       0.839          11.8        0.315E 06   1.94        0.482       0.557      0.558E-01    0.484E-01   0.644E-03    64.1
                              11.8
     1 45.0     0.138       0.708          9.49        0.292E 06   1.80        0.415       0.453      0.454E-01    0.450E-01   0.598E-03    60.0
                              9.49
     1 50.0     0.584E-0    0.573          7.12        0.273E 06   1.68        0.356       0.344      0.345E-01    0.419E-01   0.557E-03    56.4
                              7.12
     1 55.0     0.380E-0    0.522          5.99        0.280E 06   1.72        0.346       0.294      0.295E-01    0.430E-01   0.572E-03    57.6
                              5.99
     2  0.0     0.341E-0    0.512          5.65        0.290E 06   1.78        0.352       0.279      0.280E-01    0.446E-01   0.593E-03    59.3
                              5.65
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2  5.0   0.327E-0  0.504     5.45   0.292E 06   1.80   0.352   0.270       0.271E-01  0.449E-01  0.597E-03  59.6
                   5.45
2 10.0   0.320E-0  0.500     5.36   0.293E 06   1.80   0.353   0.266       0.267E-01  0.450E-01  0.599E-03  59.7
                   5.36
2 15.0   0.317E-0  0.498     5.32   0.292E 06   1.80   0.353   0.265       0.266E-01  0.450E-01  0.598E-03  59.7
                   5.32
2 20.0   0.315E-0  0.497     5.31   0.292E 06   1.80   0.353   0.264       0.265E-01  0.449E-01  0.597E-03  59.5
                   5.31
2 25.0   0.313E-0  0.496     5.30   0.291E 06   1.79   0.353   0.263       0.264E-01  0.448E-01  0.596E-03  59.4
                   5.30
2 30.0   0.313E-0  0.495     5.30   0.291E 06   1.79   0.353   0.263       0.264E-01  0.447E-01  0.594E-03  59.2
                   5.30
2 35.0   0.279E-0  0.487     5.21   0.286E 06   1.76   0.349   0.259       0.260E-01  0.440E-01  0.585E-03  58.4
                   5.21
2 40.0   0.191E-0  0.467     4.98   0.274E 06   1.69   0.336   0.248       0.248E-01  0.422E-01  0.561E-03  56.4
                   4.98
2 45.0   0.994E-0  0.438     4.66   0.259E 06   1.59   0.317   0.232       0.233E-01  0.398E-01  0.529E-03  53.6
                   4.66
2 50.0   0.486E-0  0.379     4.02   0.224E 06   1.38   0.276   0.200       0.201E-01  0.345E-01  0.459E-03  46.8
                   4.02
2 55.0   0.264E-0  0.152     1.62   0.903E 05  0.556   0.111   0.805E-01   0.808E-02  0.139E-01  0.185E-03  18.9
                   1.62
3  0.0   0.161E-0  0.0      0.0     0.0        0.0     0.0     0.0         0.0        0.0        0.0        0.0
                   0.0
3  5.0   0.107E-0  0.0      0.0     0.0        0.0     0.0     0.0         0.0        0.0        0.0        0.0
                   0.0
3 10.0   0.763E-0  0.0      0.0     0.0        0.0     0.0     0.0         0.0        0.0        0.0        0.0
                   0.0
3 15.0   0.575E-0  0.0      0.0     0.0        0.0     0.0     0.0         0.0        0.0        0.0        0.0
                   0.0
3 20.0   0.401E-0  0.0      0.0     0.0        0.0     0.0     0.0         0.0        0.0        0.0        0.0
                   0.0
```

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SWMM WORKSHOP - RUNOFF BLOCK
EXAMPLE NO 1 - 2YR DESIGN STORM, ROOF LEADERS CONNECTED

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 400

FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

  TIME     FLOW       BOD        SUS-S       COLIF        COD        SET-S      NIT        PO4         GREASE      PB          CL
                      SUS-SNE
 0  5.0   0.360E-0   0.0        0.0         0.0          0.0        0.0        0.0        0.0         0.0         0.0         0.0
                     0.0
 0 10.0   0.205E-0   39.0       0.204E 04   0.123E 07    124.       0.535      0.637      0.641E-01   0.190       0.252E-02   238.
                     12.0
 0 15.0   0.481E-0   49.3       0.161E 04   0.148E 07    156.       0.646      0.783      0.788E-01   0.228       0.304E-02   288.
                     14.8
 0 20.0   0.844E-0   52.5       0.109E 04   0.158E 07    166.       0.692      0.865      0.870E-01   0.243       0.323E-02   308.
                     16.5
 0 25.0   0.178      49.1        669.       0.162E 07    155.       0.742       1.04      0.104       0.249       0.331E-02   317.
                     20.2
 0 30.0   0.402      39.6        405.       0.161E 07    124.       0.862       1.41      0.142       0.247       0.329E-02   315.
                     28.6
 0 35.0   0.766      28.0        310.       0.155E 07    86.0        1.14       2.00      0.200       0.238       0.316E-02   304.
                     41.6
 0 40.0    1.42      17.3        374.       0.145E 07    48.7        2.01       3.14      0.314       0.223       0.296E-02   285.
                     66.9
 0 45.0    3.72      13.0        595.       0.125E 07    21.2        8.81       6.89      0.689       0.192       0.256E-02   246.
                     149.
 0 50.0    5.99      10.7        366.       0.100E 07    10.2        12.9       7.69      0.770       0.155       0.205E-02   198.
                     166.
 0 55.0    4.77      7.64        175.       0.764E 06    5.42        11.7       6.11      0.611       0.118       0.156E-02   152.
                     132.
 1  0.0    2.72      4.26        167.       0.575E 06    4.06        4.38       3.29      0.329       0.884E-01   0.118E-02   114.
                     71.2
 1  5.0    2.06      2.91        121.       0.530E 06    3.62       0.804       2.18      0.219       0.815E-01   0.108E-02   104.
                     47.5
 1 10.0    1.51      2.21        122.       0.466E 06    2.98        2.09       1.66      0.166       0.718E-01   0.954E-03   92.3
                     35.6
 1 15.0    1.09      1.58        121.       0.412E 06    2.68       0.856       1.12      0.112       0.633E-01   0.842E-03   81.6
                     23.9
 1 20.0   0.891      1.31        128.       0.387E 06    2.44       0.688      0.917      0.918E-01   0.595E-01   0.791E-03   76.5
                     19.6
 1 25.0   0.743      1.14        127.       0.363E 06    2.30       0.688      0.771      0.772E-01   0.558E-01   0.742E-03   71.9
                     16.4
 1 30.0   0.656      1.03        127.       0.350E 06    2.21       0.548      0.693      0.695E-01   0.538E-01   0.715E-03   69.2
                     14.7
 1 35.0   0.598      0.965       127.       0.339E 06    2.14       0.540      0.639      0.640E-01   0.521E-01   0.693E-03   67.0
                     13.5
 1 40.0   0.481      0.887       70.5       0.323E 06    2.03       0.492      0.581      0.582E-01   0.497E-01   0.661E-03   64.0
                     12.3
 1 45.0   0.276      0.763      0.380       0.299E 06    1.87       0.436      0.489      0.490E-01   0.460E-01   0.611E-03   59.4
                     10.3
 1 50.0   0.123      0.625       9.45       0.276E 06    1.72       0.371      0.383      0.384E-01   0.424E-01   0.564E-03   55.3
                     7.98
 1 55.0   0.743E-0   0.551       6.50       0.277E 06    1.73       0.345      0.314      0.315E-01   0.427E-01   0.567E-03   55.6
                     6.44
 2  0.0   0.656E-0   0.536       5.91       0.289E 06    1.82       0.347      0.290      0.291E-01   0.445E-01   0.592E-03   57.6
                     5.90
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2  5.0   0.628E-0  0.530          5.66     0.295E 06   1.85    0.349      0.280      0.281E-01  0.454E-01  0.603E-03   58.4
                   5.66
2 10.0   0.614E-0  0.527          5.55     0.297E 06   1.87    0.350      0.275      0.276E-01  0.457E-01  0.608E-03   58.8
                   5.55
2 15.0   0.608E-0  0.525          5.50     0.298E 06   1.87    0.351      0.273      0.274E-01  0.458E-01  0.609E-03   58.8
                   5.50
2 20.0   0.604E-0  0.524          5.48     0.298E 06   1.87    0.351      0.272      0.273E-01  0.458E-01  0.609E-03   58.8
                   5.48
2 25.0   0.602E-0  0.523          5.47     0.297E 06   1.87    0.351      0.272      0.273E-01  0.457E-01  0.608E-03   58.6
                   5.47
2 30.0   0.600E-0  0.522          5.47     0.296E 06   1.87    0.351      0.272      0.272E-01  0.456E-01  0.606E-03   58.5
                   5.47
2 35.0   0.550E-0  0.513          5.39     0.292E 06   1.83    0.347      0.267      0.268E-01  0.449E-01  0.596E-03   57.6
                   5.39
2 40.0   0.403E-0  0.487          5.13     0.278E 06   1.74    0.335      0.255      0.256E-01  0.428E-01  0.569E-03   55.1
                   5.13
2 45.0   0.230E-0  0.449          4.76     0.259E 06   1.61    0.316      0.237      0.237E-01  0.398E-01  0.530E-03   51.7
                   4.76
2 50.0   0.118E-0  0.406          4.32     0.236E 06   1.46    0.291      0.215      0.215E-01  0.363E-01  0.483E-03   47.6
                   4.32
2 55.0   0.651E-0  0.335          3.57     0.196E 06   1.21    0.241      0.177      0.178E-01  0.301E-01  0.401E-03   39.8
                   3.57
3  0.0   0.400E-0  0.237          2.51     0.138E 06  0.856    0.171      0.125      0.125E-01  0.213E-01  0.283E-03   28.2
                   2.51
3  5.0   0.259E-0  0.909E-01    0.965      0.532E 05  0.329    0.654E-01  0.480E-01  0.482E-02  0.818E-02  0.109E-03   10.8
                   0.965
3 10.0   0.176E-0  0.0          0.0        0.0        0.0      0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
3 15.0   0.129E-0  0.0          0.0        0.0        0.0      0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
3 20.0   0.979E-0  0.0          0.0        0.0        0.0      0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
```

```
TOTAL SUSPENDED SOLIDS (INCLUDING S.S. FROM EROSION) TRANSFERRED TO THE SEWER FROM INLET AREAS DURING  40 TIME STEPS

INLET    EROSION       FLOW       SOIL    CROPPING  CONTROL     EROSION     TOTAL
 NO.  AREA(ACRES)  LENGTH(FT)  TYPE(K)   FACTOR    FACTOR     S.S.(MG)   S.S.(MG)

  1       0.0          0.0       0.0       0.0       0.0     0.0         0.8664E 07
  2       0.0          0.0       0.0       0.0       0.0     0.0         0.7089E 07
  3       0.0          0.0       0.0       0.0       0.0     0.0         0.4161E 07
  4       0.78       110.00      0.20      1.00      1.20    0.4032E 08 0.4328E 08


       TOTAL EROSION CONTRIBUTION              TOTAL SUS-S

           0.40323E 08 MG                   0.63197E 08 MG

                  88.8 LB                          139.2 LB
```

RUNOFF BLOCK WORKSHOP EXAMPLES NO. 2 AND NO.3

2nd EXAMPLE

Assumptions: 1) All roof leaders are connected

2) 5-year design storm

Five-Year Design Storm:

5 min	.18/in hr	40 min	1.46 in/hr	75 min	.40 in/hr
10	.20	45	4.43	80	.35
15	.23	50	1.87	85	.31
20	.27	55	1.06	90	.28
25	.33	60	.74	95	.26
30	.43	65	.57	100	.29
35	.65	70	.47		

3rd EXAMPLE

Assumptions: 1) No roof leaders are connected.

2) 5-year design storm.

New Imperviousness - Area #1 = 21.5%

#2 = 19.0%

#3 = 14.7%

#4 = 18.0%

```
         SWMM WORKSHOP - RUNOFF BLOCK

         EXAMPLE NO.2 - 5YR DESIGN STORM, ROOF LEADERS CONNECTED
```

REMAINDER OF OUTPUT NOT INCLUDED
IS IDENTICAL TO EXAMPLE 1

```
 BASIN NUMBER    0

 NUMBER OF TIME STEPS    40

 INTEGRATION TIME INTERVAL (MINUTES),     5.00

 25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

 EROSION FOR SUBCATCHMENTS IS TO BE MODELED.
 HIGHEST 30 MIN. RAIN INTENSITY IS  1.70 IN/HR

 FOR  21 RAINFALL STEPS, THE TIME INTERVAL IS   5.00 MINUTES


 FOR RAINGAGE NUMBER  1,  RAINFALL HISTORY IS

      0.21      0.20      0.23      0.27      0.33      0.43      0.65      1.46      4.43      1.87
      1.06      0.74      0.57      0.47      0.40      0.35      0.31      0.28      0.26      0.24
      0.0

   DEGREE HOUR MELT RATE =    0.0

  TEMPERATURE OF SNOW BASE =      30.0

  WIND FACTOR =          0.00500

  GAMMA FACTOR =          0.07913

  TEMPERATURE AT EACH TIME STEP
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
```

EXAMPLE NO. 2

```
HYDROGRAPHS WILL BE LISTED FOR THE FOLLOWING   4 GUTTERS OR INLETS

         100  200  300  400

GUTTER    1 SURCHARGED, SURCHARGE =        273. CU FT, FLOW =        3.8 CFS, TIME      2700.0 SEC
GUTTER    3 SURCHARGED, SURCHARGE =        239. CU FT, FLOW =        6.2 CFS, TIME      2700.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       1150. CU FT, FLOW =        8.0 CFS, TIME      2700.0 SEC
GUTTER    1 SURCHARGED, SURCHARGE =        766. CU FT, FLOW =        3.8 CFS, TIME      3000.0 SEC
GUTTER    2 SURCHARGED, SURCHARGE =        139. CU FT, FLOW =        3.8 CFS, TIME      3000.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       2144. CU FT, FLOW =        8.0 CFS, TIME      3000.0 SEC
GUTTER    1 SURCHARGED, SURCHARGE =        902. CU FT, FLOW =        3.8 CFS, TIME      3300.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       2838. CU FT, FLOW =        8.0 CFS, TIME      3300.0 SEC
GUTTER    1 SURCHARGED, SURCHARGE =        566. CU FT, FLOW =        3.8 CFS, TIME      3600.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       2739. CU FT, FLOW =        8.0 CFS, TIME      3600.0 SEC
GUTTER    1 SURCHARGED, SURCHARGE =          1. CU FT, FLOW =        3.8 CFS, TIME      3900.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       2186. CU FT, FLOW =        8.0 CFS, TIME      3900.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       1059. CU FT, FLOW =        8.0 CFS, TIME      4200.0 SEC

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFF50000A216CB9C , REGISTER CONTAINED   7D1000003C000000

TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14    REG. 15    REG.  0    REG.  1

             WSHED              0096    42165C5C   0016C4C0   00000098   00000000

             HYDRO              0010    621650BA   00165140   00000001   0016502C

            RUNOFF              0051    42145E22   00164EF0   00000001   00000000

              MAIN                      00017982   011455C0   FD000008   0018F7F8

ENTRY POINT=  011455C0

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFF50000A216CB9C , REGISTER CONTAINED   7D1000003C000000

TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14    REG. 15    REG.  0    REG.  1

             WSHED              0096    42165C5C   0016C4C0   00000098   00000000

             HYDRO              0010    621650BA   00165140   00000001   0016502C

            RUNOFF              0051    42145E22   00164EF0   00000001   00000000

              MAIN                      00017982   011455C0   FD000008   0018F7F8

ENTRY POINT=  011455C0

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFF50000A216CB9C , REGISTER CONTAINED   7D1000003C000000

TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14    REG. 15    REG.  0    REG.  1

             WSHED              0096    42165C5C   0016C4C0   00000098   00000000

             HYDRO              0010    621650BA   00165140   00000001   0016502C

            RUNOFF              0051    42145E22   00164EF0   00000001   00000000
```

```
              MAIN                       00017982   011455C0   FD000008   0018F7F8

ENTRY POINT=  011455C0

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFF5000DA216CB9C . REGISTER CONTAINED   7D1000003C000000

TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14   REG. 15   REG.  0   REG.  1

             WSHED         0096      42165C5C  0016C4C0  00000098  00000000

             HYDRO         0010      621650BA  00165140  00000001  0016502C

            RUNOFF         0051      42145E22  00164EF0  00000001  00000000

              MAIN                   00017982  011455C0  FD000008  0018F7F8

ENTRY POINT=  011455C0

STANDARD FIXUP TAKEN , EXECUTION CONTINUING



TOTAL RAINFALL (CU FT)                   0.295124E 05

TOTAL INFILTRATION (CU FT)               0.153869E 05

TOTAL GUTTER FLOW AT INLET (CU FT)       0.201728E 05

TOTAL SURFACE STORAGE AT END OF STORM (CU FT)0.494146E 03

TOTAL SNOWMELT (CU FT)                   0.389293E 04

ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL,   -7.92828
```

```
* * * * *   S U M M A R Y   O F   F I N A L   S N O W   C O N D I T I O N S   * * * * *

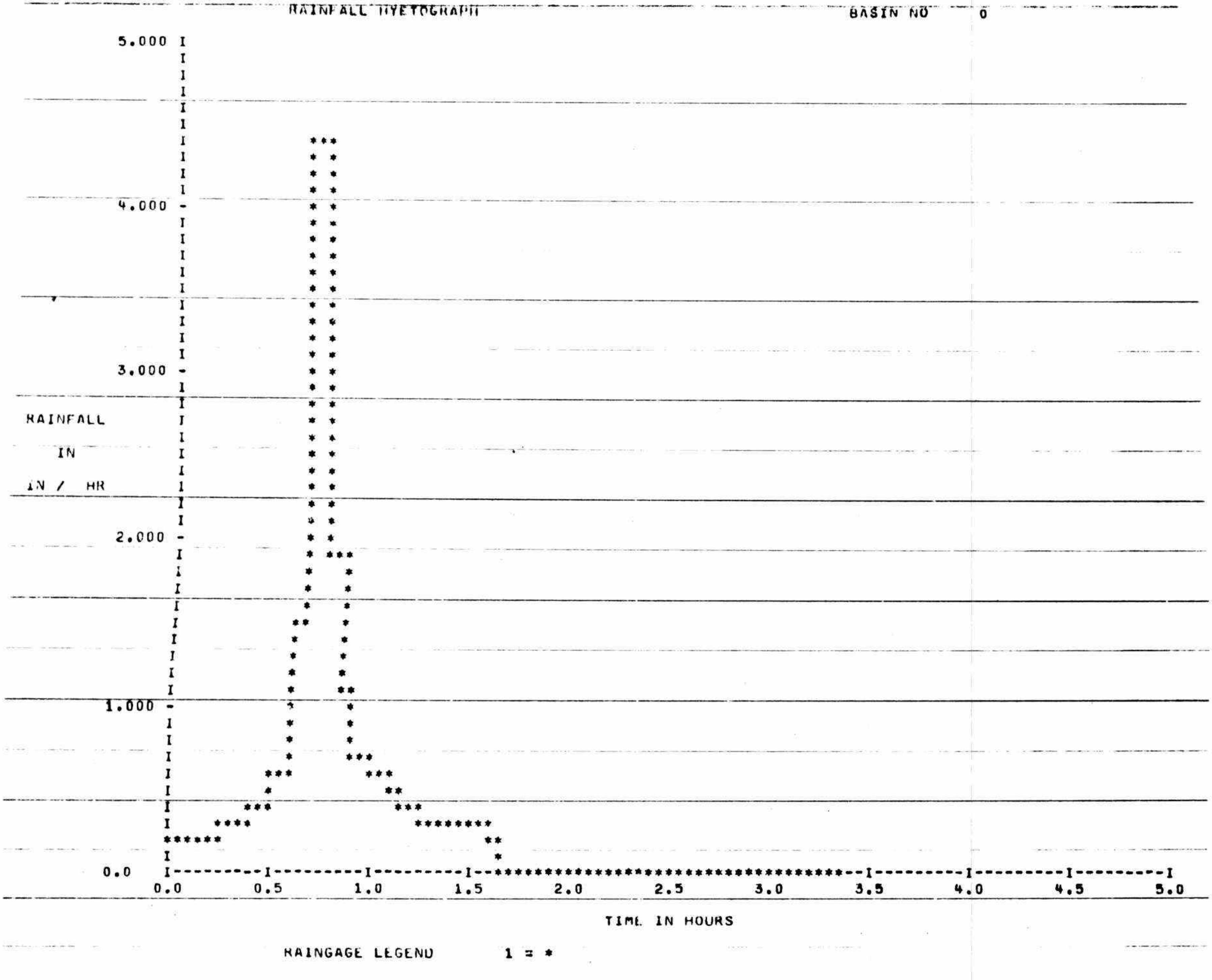
WATERSHED    SNOW COVERED AREA (SQFT)         DEPTH OF SNOW (FT)              FREE WATER (FT)
               IMPERV          PERV         IMPERV          PERV          IMPERV          PERV

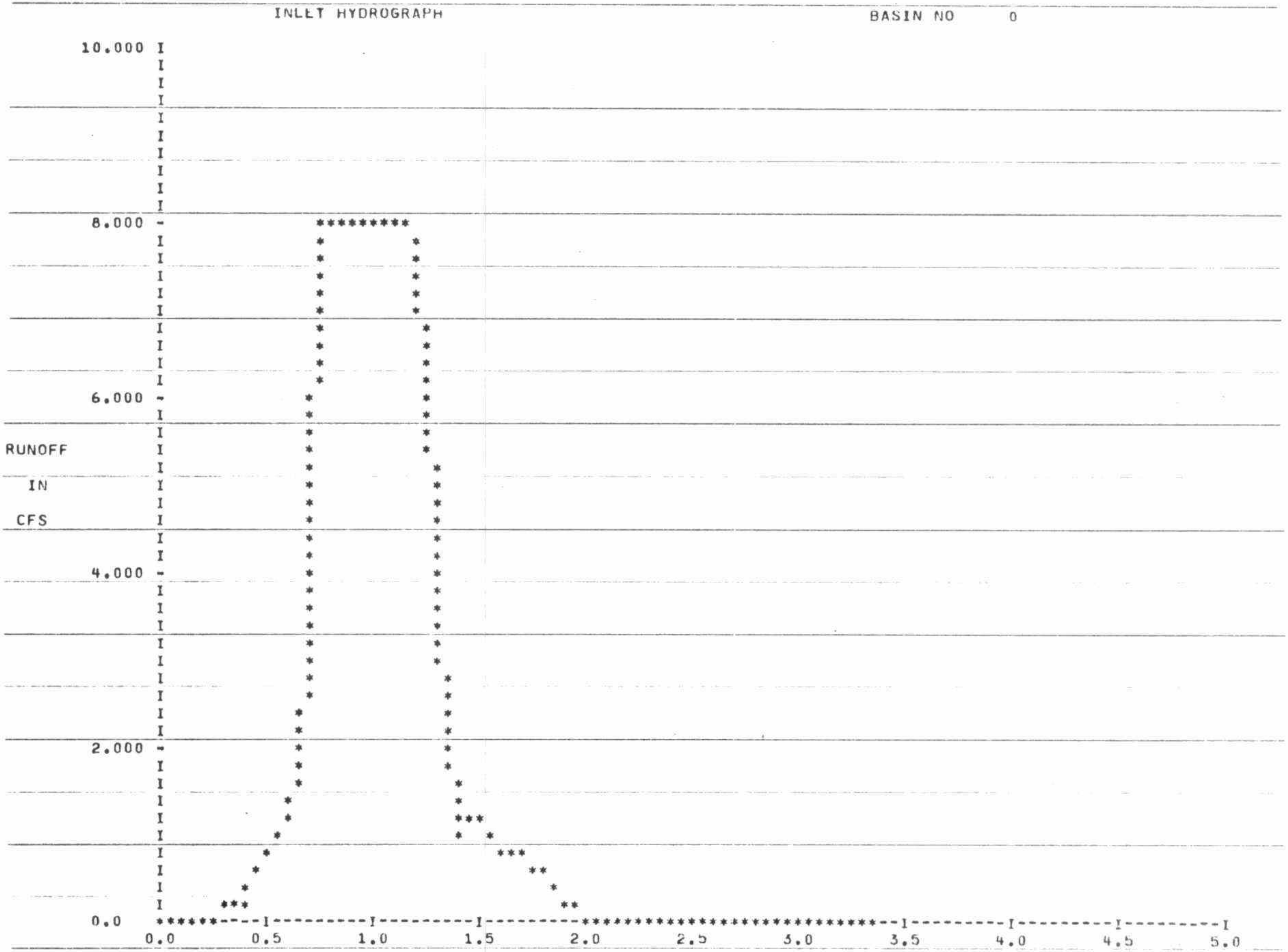
    1          13529.         47785.          0.0          0.02158          0.0          0.00043

    2          12688.         28330.          0.0          0.02158          0.0          0.00043

    3           2525.         14640.          0.0          0.02158          0.0          0.00043

    4           2066.         20960.          0.0          0.02158          0.0          0.00043
```


RAINFALL HYETOGRAPH
BASIN NO 0
5.000
4.000
3.000
2.000
1.000
0.0
RAINFALL
IN
IN / HR
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
TIME IN HOURS
RAINGAGE LEGEND 1 = *


INLET HYDROGRAPH
BASIN NO 0
10.000
8.000
6.000
4.000
2.000
0.0
RUNOFF
IN
CFS
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

NOTE: INSTABILITY DUE TO
1. SURCHARGE CONDITION
2. STEEP HYETOGRAPH

```
SWMM WORKSHOP - RUNOFF BLOCK
EXAMPLE NO.2 - 5YR DESIGN STORM, ROOF LEADERS CONNECTED

SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 100


FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

  TIME    FLOW       BOD          SUS-S                               SET-S       NIT         PO4         GREASE      PB          CL
                     SUS-SNE
0  5.0    0.142E-0   0.0          0.0        0.0         0.0          0.0         0.0         0.0         0.0         0.0         0.0
                     0.0
0 10.0    0.428E-0   40.5         9.92       0.914E 06   127.         0.402       0.518       0.521E-01   0.141       0.187E-02   192.
                     9.92
0 15.0    0.541E-0   49.8         13.2       0.118E 07   157.         0.523       0.687       0.690E-01   0.182       0.242E-02   249.
                     13.2
0 20.0    0.137      45.2         18.2       0.126E 07   142.         0.603       0.920       0.924E-01   0.194       0.257E-02   265.
                     18.2
0 25.0    0.319      32.1         29.8       0.124E 07   99.5         0.811       1.44        0.144       0.191       0.255E-02   262.
                     29.8
0 30.0    0.482      19.0         42.0       0.120E 07   56.7         1.12        1.99        0.199       0.184       0.245E-02   252.
                     42.0
0 35.0    0.666      9.24         55.9       0.112E 07   24.1         1.61        2.61        0.262       0.173       0.230E-02   236.
                     55.9
0 40.0      1.23     6.39         91.1       0.100E 07   9.23         3.54        4.21        0.421       0.154       0.205E-02   211.
                     91.1
0 45.0      3.52     -0.304E 56   74.9       0.444E 06   2.86         6.07        3.48        0.348       0.684E-01   0.909E-03 -0.383E 27
                     74.9
0 50.0      5.48     -0.227E 56   95.3       0.477E 06   2.93         8.94        4.43        0.443       0.734E-01   0.976E-03 -0.286E 27
                     95.3
0 55.0      4.29     0.573E 55    68.4       0.352E 06   2.17         6.02        3.18        0.318       0.542E-01   0.721E-03  0.722E 26
                     68.4
1  0.0      2.71     -0.144E 55   68.7       0.351E 06   2.16         5.25        3.19        0.319       0.539E-01   0.717E-03 -0.182E 26
                     68.7
1  5.0      1.95     0.364E 54    96.4       0.497E 06   3.06         6.63        4.48        0.448       0.765E-01   0.102E-02  0.459E 25
                     96.4
1 10.0      1.31     -0.168E 54   80.9       0.427E 06   2.63         5.30        3.75        0.375       0.658E-01   0.874E-03 -0.212E 25
                     80.9
1 15.0    0.998      0.112E 54    -38.9     -0.158E 06  -0.975       -2.75       -1.81       -0.181      -0.243E-01  -0.323E-03  0.141E 25
                     -38.9
1 20.0    0.739      -0.559E 52   8.41       0.765E 05   0.471        0.441       0.389       0.390E-01   0.118E-01   0.156E-03 -0.704E 23
                     8.41
1 25.0    0.587      0.116E 52    3.80       0.554E 05   0.341        0.146       0.176       0.177E-01   0.852E-02   0.113E-03  0.146E 23
                     3.80
1 30.0    0.474      -0.930E 50   3.67       0.544E 05   0.335        0.150       0.171       0.171E-01   0.837E-02   0.111E-03 -0.117E 22
                     3.67
1 35.0    0.403      0.593E 49    3.03       0.509E 05   0.313        0.120       0.142       0.142E-01   0.782E-02   0.104E-03  0.748E 20
                     3.03
1 40.0    0.355      -0.123E 48   2.69       0.483E 05   0.297        0.106       0.126       0.126E-01   0.743E-02   0.988E-04 -0.155E 19
                     2.69
1 45.0    0.237      -0.339E 45   2.30       0.464E 05   0.286        0.916E-01   0.108       0.108E-01   0.714E-02   0.949E-04 -0.427E 16
                     2.30
1 50.0    0.817E-0   -0.126E 44   1.75       0.452E 05   0.278        0.746E-01   0.828E-01   0.829E-02   0.695E-02   0.924E-04 -0.159E 15
                     1.75
1 55.0    0.294E-0   -0.269E 43   1.20       0.445E 05   0.274        0.626E-01   0.581E-01   0.583E-02   0.684E-02   0.909E-04 -0.339E 14
                     1.20
2  0.0    0.293E-0   -0.105E 43   1.00       0.442E 05   0.272        0.595E-01   0.489E-01   0.491E-02   0.680E-02   0.903E-04 -0.132E 14
                     1.00
```

INSTABILITY

```
2  5.0   0.275E-0 -0.405E 42  0.919      0.439E 05  0.270      0.582E-01  0.452E-01  0.453E-02  0.676E-02  0.899E-04 -0.510E 13
                   0.919
2 10.0   0.271E-0 -0.156E 42  0.884      0.438E 05  0.269      0.577E-01  0.436E-01  0.437E-02  0.673E-02  0.895E-04 -0.197E 13
                   0.884
2 15.0   0.237E-0 -0.624E 41  0.866      0.436E 05  0.268      0.575E-01  0.428E-01  0.429E-02  0.671E-02  0.892E-04 -0.787E 12
                   0.866
2 20.0   0.139E-0 -0.291E 41  0.847      0.435E 05  0.267      0.573E-01  0.419E-01  0.420E-02  0.669E-02  0.889E-04 -0.366E 12
                   0.847
2 25.0   0.432E-0 -0.175E 41  0.823      0.431E 05  0.266      0.569E-01  0.408E-01  0.409E-02  0.664E-02  0.882E-04 -0.220E 12
                   0.823
2 30.0   0.106E-0 -0.138E 41  0.804      0.427E 05  0.263      0.564E-01  0.399E-01  0.400E-02  0.658E-02  0.874E-04 -0.173E 12
                   0.804
2 35.0   0.586E-0 -0.638E 40  0.400      0.214E 05  0.132      0.282E-01  0.199E-01  0.199E-02  0.329E-02  0.437E-04 -0.804E 11
                   0.400
2 40.0   0.389E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
2 45.0   0.282E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
2 50.0   0.216E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
2 55.0   0.171E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
3  0.0   0.140E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
3  5.0   0.116E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
3 10.0   0.980E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
3 15.0   0.839E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
3 20.0   0.726E-0  0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0
                   0.0
```

SIMILAR OUTPUT FOR
LOCATIONS 200, 300, 400

```
TOTAL SUSPENDED SOLIDS (INCLUDING S.S. FROM EROSION) TRANSFERRED TO THE SEWER FROM INLET AREAS DURING  40 TIME STEPS

INLET    EROSION       FLOW        SOIL     CROPPING  CONTROL      EROSION      TOTAL
 NO.  AREA(ACRES)  LENGTH(FT)   TYPE(K)    FACTOR    FACTOR      S.S.(MG)    S.S.(MG)

  1       0.0          0.0        0.0        0.0       0.0     0.0          0.1226E 08
  2       0.0          0.0        0.0        0.0       0.0     0.0          0.9041E 07
  3       0.0          0.0        0.0        0.0       0.0     0.0          0.6670E 07
  4       0.78       110.00       0.20       1.00      1.20    0.1068E 09   0.1144E 09

        TOTAL EROSION CONTRIBUTION              TOTAL SUS-S

              0.10679E 09 MG                  0.14236E 09 MG
                     235.2 LB                       313.6 LB
```

REMAINDER OF OUTPUT NOT INCLUDED IS SIMILAR TO EXAMPLE I

```
         SWMM WORKSHOP - RUNOFF BLOCK

         EXAMPLE NO.3 - 5YR DESIGN STORM, ROOF LEADERS ARE DISCONNECTED


BASIN NUMBER    1

NUMBER OF TIME STEPS    40

INTEGRATION TIME INTERVAL (MINUTES),     5.00

25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

EROSION FOR SUBCATCHMENTS IS TO BE MODELED.
HIGHEST 30 MIN. RAIN INTENSITY IS  1.70 IN/HR

FOR  21 RAINFALL STEPS, THE TIME INTERVAL IS    5.00 MINUTES


FOR RAINGAGE NUMBER  1,  RAINFALL HISTORY IS

     0.21       0.20       0.23       0.27       0.33       0.43       0.65       1.46       4.43       1.87
     1.06       0.74       0.57       0.47       0.40       0.35       0.31       0.28       0.26       0.24
     0.0

  DEGREE HOUR MELT RATE =    0.0

 TEMPERATURE OF SNOW BASE =       30.0

 WIND FACTOR =          0.00500

 GAMMA FACTOR =          0.07913

 TEMPERATURE AT EACH TIME STEP
      40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0
      40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0
      40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0
      40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0       40.0
```

EXAMPLE NO. 3

```
* * * * *  S U B C A T C H M E N T   D A T A  * * * * *

SUBCATCH-  GUTTER    WIDTH    AREA   PERCENT    SLOPE     RESISTANCE FACTOR   SURFACE STORAGE(IN)     INFILTRATION   DECAY RATE  GAGE
MENT NO.  OR INLET   (FT)     (AC)   IMPERV.   (FT/FT)    IMPERV.     PERV.    IMPERV.      PERV.      RATE(IN/HR)     (1/SEC)     NO.
                                                                                                    MAXIMUM MINIMUM
   1    1    100    1021.0      2.9   21.5     0.030      0.013      0.250     0.062      0.184      3.00     0.52     0.00115      1
   2    2    200     752.0      1.9   19.0     0.030      0.013      0.250     0.062      0.184      3.00     0.52     0.00115      1
   3    3    300     529.0      0.8   14.7     0.030      0.013      0.250     0.062      0.184      3.00     0.52     0.00115      1
   4    4    400     579.0      0.9   18.0     0.030      0.013      0.250     0.062      0.184      3.00     0.52     0.00115      1

TOTAL NUMBER OF SUBCATCHMENTS,     4

TOTAL TRIBUTARY AREA (ACRES),     6.61
```

REDUCED IMPERVIOUSNESS

```
HYDROGRAPHS WILL BE LISTED FOR THE FOLLOWING   4 GUTTERS OR INLETS

          100  200  300  400

GUTTER    1 SURCHARGED, SURCHARGE =       142. CU FT, FLOW =        3.8 CFS, TIME      3000.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       486. CU FT, FLOW =        8.0 CFS, TIME      3000.0 SEC
GUTTER    1 SURCHARGED, SURCHARGE =        56. CU FT, FLOW =        3.8 CFS, TIME      3300.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       793. CU FT, FLOW =        8.0 CFS, TIME      3300.0 SEC
GUTTER    4 SURCHARGED, SURCHARGE =       429. CU FT, FLOW =        8.0 CFS, TIME      3600.0 SEC

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFC5000DA218939C . REGISTER CONTAINED   7D1000003C000000

TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14   REG. 15   REG.  0   REG.  1

                WSHED            0096   4218245C   00188CC0   00000098   00000000

                HYDRO            0010   6218188A   00181940   00000001   0018182C

               RUNOFF            0051   42162622   001816F0   00000001   00000000

                 MAIN                   00017982   01161DC0   FD000008   001ABFF8

ENTRY POINT=  01161DC0

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFC5000DA218939C . REGISTER CONTAINED   7D1000003C000000

TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14   REG. 15   REG.  0   REG.  1

                WSHED            0096   4218245C   00188CC0   00000098   00000000

                HYDRO            0010   6218188A   00181940   00000001   0018182C

               RUNOFF            0051   42162622   001816F0   00000001   00000000

                 MAIN                   00017982   01161DC0   FD000008   001ABFF8

ENTRY POINT=  01161DC0

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFC5000DA218939C . REGISTER CONTAINED   7D1000003C000000

TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14   REG. 15   REG.  0   REG.  1

                WSHED            0096   4218245C   00188CC0   00000098   00000000

                HYDRO            0010   6218188A   00181940   00000001   0018182C

               RUNOFF            0051   42162622   001816F0   00000001   00000000

                 MAIN                   00017982   01161DC0   FD000008   001ABFF8

ENTRY POINT=  01161DC0

STANDARD FIXUP TAKEN , EXECUTION CONTINUING

IHC208I IBCOM - PROGRAM INTERRUPT (P) -  UNDERFLOW   OLD PSW IS  FFC5000DA218939C . REGISTER CONTAINED   7D1000003C000000
```

```
TRACEBACK  ROUTINE  CALLED FROM ISN   REG. 14   REG. 15   REG.  0   REG.  1
              WSHED             0096  4218245C  00188CC0  00000098  00000000
              HYDRO             0010  6218188A  00181940  00000001  0018182C
             RUNOFF             0051  42162622  001816F0  00000001  00000000
               MAIN                   00017982  01161DC0  FD000008  001ABFF8
ENTRY POINT=  01161DC0
STANDARD FIXUP TAKEN . EXECUTION CONTINUING


TOTAL RAINFALL (CU FT)                          0.295124E 05
TOTAL INFILTRATION (CU FT)                      0.211814E 05
TOTAL GUTTER FLOW AT INLET (CU FT)              0.140449E 05
TOTAL SURFACE STORAGE AT END OF STORM (CU FT)0.234547E 03
TOTAL SNOWMELT (CU FT)                          0.473110E 04
ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL,     -3.55502
```

```
* * * * *   S U M M A R Y   O F   F I N A L   S N O W   C O N D I T I O N S   * * * * *

WATERSHED    SNOW COVERED AREA (SQFT)       DEPTH OF SNOW (FT)            FREE WATER (FT)
              IMPERV          PERV         IMPERV          PERV          IMPERV          PERV

    1          6860.          65124.       0.0            0.02158        0.0            0.00043

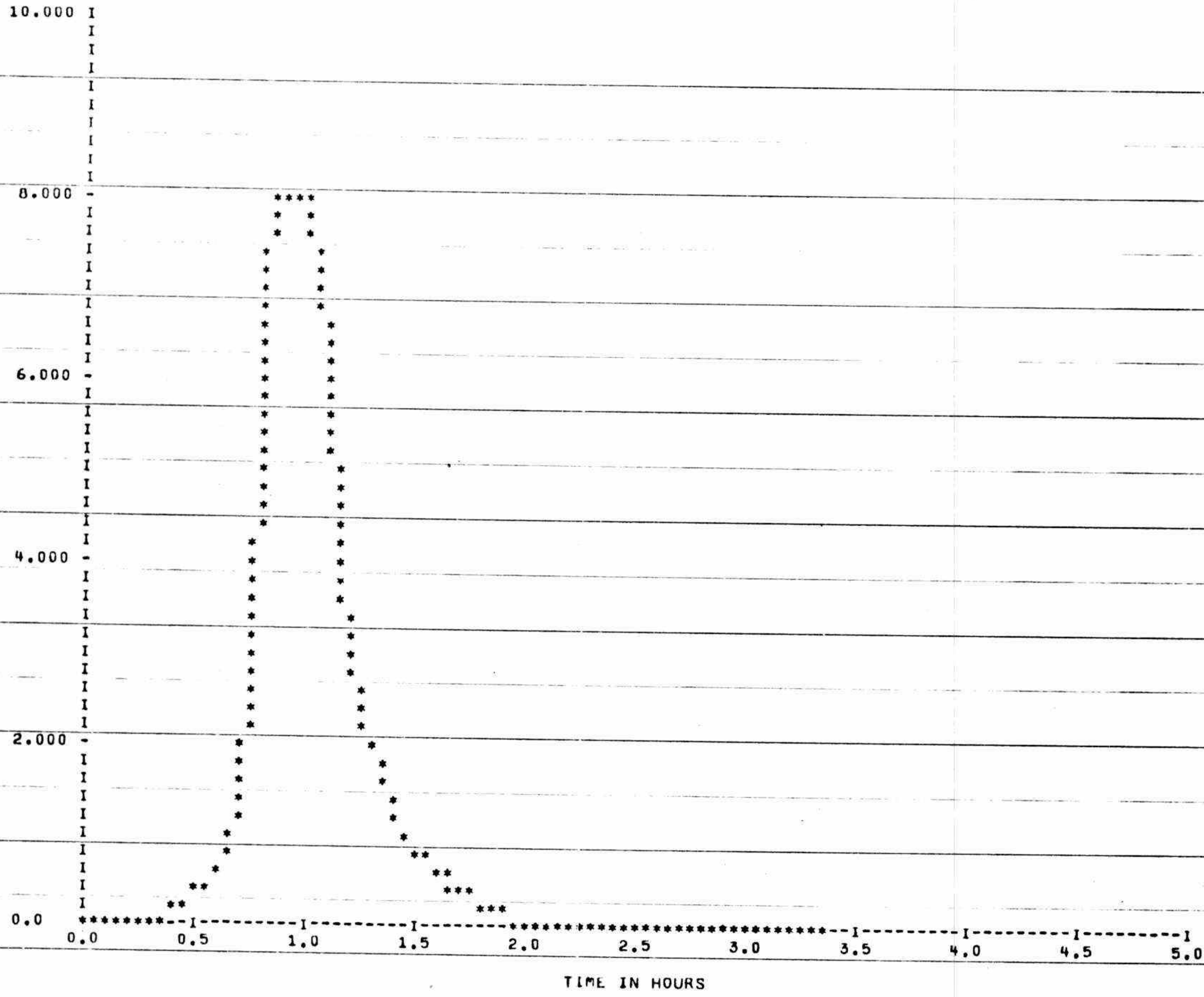
    2          4718.          46927.       0.0            0.02158        0.0            0.00043

    3          1089.          18950.       0.0            0.02158        0.0            0.00043

    4          1823.          21592.       0.0            0.02158        0.0            0.00043
```

INLET HYDROGRAPH

BASIN NO 1



```
SWMM WORKSHOP - RUNOFF BLOCK
EXAMPLE NO.3 - 5YR DESIGN STORM, ROOF LEADERS ARE DISCONNECTED


SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION 100


FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

    TIME     FLOW        BOD         SUS-S       F           COD         SET-S       NIT         PO4         GREASE      PB          CL
                         SUS-SNE
  0  5.0     0.860E-0    0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0         0.0
                         0.0
  0 10.0     0.230E-0    40.2        8.54        0.069E 06   127.        0.377       0.452       0.455E-01   0.134       0.178E-02   183.
                         8.54
  0 15.0     0.275E-0    52.0        11.5        0.115E 07   164.        0.501       0.606       0.609E-01   0.177       0.236E-02   243.
                         11.5
  0 20.0     0.759E-0    51.9        14.7        0.126E 07   163.        0.563       0.759       0.763E-01   0.193       0.257E-02   265.
                         14.7
  0 25.0     0.176       43.3        20.8        0.127E 07   136.        0.640       1.03        0.104       0.195       0.259E-02   267.
                         20.8
  0 30.0     0.253       31.8        26.5        0.125E 07   99.0        0.732       1.29        0.130       0.192       0.255E-02   262.
                         26.5
  0 35.0     0.344       19.4        33.2        0.121E 07   59.5        0.874       1.59        0.159       0.185       0.247E-02   254.
                         33.2
  0 40.0     0.646       10.0        52.2        0.114E 07   27.2        1.49        2.45        0.245       0.175       0.232E-02   239.
                         52.2
  0 45.0     1.89        8.76        135.        0.979E 06   9.46        6.96        6.23        0.623       0.151       0.200E-02   206.
                         135.
  0 50.0     3.52        -0.496E 27  97.4        -0.147E 39  3.54        7.61        -0.280E 20  -0.498E 27  0.840E-01   -1.43       -0.498E 27
                         97.4
  0 55.0     3.55        -0.371E 27  93.9        -0.110E 39  3.07        9.15        -0.210E 20  -0.372E 27  0.778E-01   -1.07       -0.372E 27
                         93.9
  1  0.0     2.63        0.113E 27   72.6        0.333E 38   2.44        6.44        0.637E 19   0.113E 27   0.608E-01   0.325       0.113E 27
                         72.6
  1  5.0     1.88        -0.437E 26  42.6        -0.129E 38  1.47        3.00        -0.247E 19  -0.439E 26  0.370E-01   -0.125      -0.439E 26
                         42.6
  1 10.0     1.29        0.161E 26   24.6        0.476E 37   1.10        1.38        0.910E 18   0.162E 26   0.274E-01   0.467E-01   0.162E 26
                         24.6
  1 15.0     0.928       -0.443E 25  15.4        -0.131E 37  0.965       0.817       -0.251E 18  -0.445E 25  0.241E-01   -0.125E-01  -0.445E 25
                         15.4
  1 20.0     0.646       0.944E 24   11.0        0.279E 36   0.855       0.510       0.534E 17   0.948E 24   0.214E-01   0.301E-02   0.948E 24
                         11.0
  1 25.0     0.467       -0.145E 24  7.87        -0.429E 35  0.788       0.332       -0.820E 16  -0.145E 24  0.197E-01   -0.156E-03  -0.146E 24
                         7.87
  1 30.0     0.337       0.112E 23   6.08        0.332E 34   0.744       0.247       0.636E 15   0.113E 23   0.186E-01   0.280E-03   0.113E 23
                         6.08
  1 35.0     0.261       -0.210E 21  4.84        -0.620E 32  0.712       0.197       -0.119E 14  -0.211E 21  0.178E-01   0.236E-03   -0.211E 21
                         4.84
  1 40.0     0.203       -0.862E 19  4.09        -0.255E 31  0.689       0.172       -0.488E 12  -0.865E 19  0.172E-01   0.229E-03   -0.865E 19
                         4.09
  1 45.0     0.119       -0.818E 18  3.43        -0.242E 30  0.673       0.154       -0.463E 11  -0.821E 18  0.168E-01   0.224E-03   -0.821E 18
                         3.43
  1 50.0     0.327E-0    -0.163E 18  2.77        -0.483E 29  0.663       0.140       -0.924E 10  -0.164E 18  0.166E-01   0.220E-03   -0.164E 18
                         2.77
  1 55.0     0.126E-0    -0.730E 17  2.26        -0.216E 29  0.658       0.132       -0.413E 10  -0.733E 17  0.165E-01   0.219E-03   -0.733E 17
                         2.26
  2  0.0     0.139E-0    -0.392E 17  2.01        -0.116E 29  0.654       0.129       -0.222E 10  -0.393E 17  0.164E-01   0.217E-03   -0.393E 17
                         2.01
```

```
 2  5.0   0.132E-0 -0.191E 17    1.86      -0.565E 28  0.651      0.127     -0.108E 10 -0.192E 17  0.163E-01  0.216E-03 -0.192E 17
                      1.86
 2 10.0   0.134E-0 -0.910E 16    1.78      -0.269E 28  0.648      0.126     -0.515E 09 -0.914E 16  0.162E-01  0.215E-03 -0.914E 16
                      1.78
 2 15.0   0.115E-0 -0.446E 16    1.74      -0.132E 28  0.646      0.125     -0.252E 09 -0.448E 16  0.161E-01  0.215E-03 -0.448E 16
                      1.74
 2 20.0   0.620E-0 -0.251E 16    1.70      -0.742E 27  0.641      0.124     -0.142E 09 -0.252E 16  0.160E-01  0.213E-03 -0.252E 16
                      1.70
 2 25.0   0.140E-0 -0.179E 16    1.67      -0.530E 27  0.637      0.123     -0.101E 09 -0.180E 16  0.159E-01  0.212E-03 -0.180E 16
                      1.67
 2 30.0   0.150E-0 -0.814E 15  0.833       -0.241E 27  0.319      0.617E-01 -0.460E 08 -0.817E 15  0.797E-02  0.106E-03 -0.817E 15
                     0.833
 2 35.0   0.869E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 2 40.0   0.586E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 2 45.0   0.430E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 2 50.0   0.332E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 2 55.0   0.266E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 3  0.0   0.218E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 3  5.0   0.182E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 3 10.0   0.155E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 3 15.0   0.135E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
 3 20.0   0.116E-0  0.0        0.0         0.0         0.0        0.0        0.0        0.0        0.0        0.0        0.0
                    0.0
```

SIMILAR OUTPUT FOR
LOCATIONS 200, 300, 400

```
TOTAL SUSPENDED SOLIDS (INCLUDING S.S. FROM EROSION) TRANSFERRED TO THE SEWER FROM INLET AREAS DURING  40 TIME STEPS

INLET    EROSION        FLOW        SOIL     CROPPING   CONTROL      EROSION      TOTAL
 NO.  AREA(ACRES)  LENGTH(FT)   TYPE(K)    FACTOR     FACTOR     S.S.(MG)    S.S.(MG)

  1       0.0           0.0         0.0        0.0        0.0    0.0          0.1127E 08
  2       0.0           0.0         0.0        0.0        0.0    0.0          0.8050E 07
  3       0.0           0.0         0.0        0.0        0.0    0.0          0.6085E 07
  4       0.78        110.00        0.20       1.00       1.20   0.1068E 09 0.1143E 09


        TOTAL EROSION CONTRIBUTION                  TOTAL SUS-S


             0.10679E 09 MG                      0.13968E 09 MG

                    235.2 LB                            307.7 LB
```

TRANSPORT BLOCK

WORKSHOP

Proctor & Redfern Limited

Consulting Engineers

SHEET 1 OF 3

PROGRAM NAME SWMM

EO NO

CARD TYPE TRANSPORT

DATE

```
TRANSPORT

      CARD GROUP  1
  0    1

      CARD GROUPS 2  THROUGH /0  OMMITTED

      CARD GROUP 11
BRUCEWOOD - QUANTITY MODELING ONLY

      CARD GROUP 12
 15  80         3   8   8   0   0   4

      CARD GROUP 13
      300.    .0001         0

      CARD GROUP 14
  0   0   0   1   0   0

      CARD GROUP 15
 1               16
 2 101           16
 3 102           16
```

Proctor & Redfern Limited

Consulting Engineers

SHEET 2 OF 3

PROGRAM NAME

ED NO

CARD TYPE

DATE

```
   4 103          16
   5 104          16
   6 105          16
   7 106          16
   8 107          16
 101   1           1   278.1     3.3    0.33   0.013
 102   2           1   238.8     3.3    0.43   0.013
 103   3           1   108.7     3.3    0.51   0.013
 104   4           1   296.1     3.3    0.48   0.013
 105   5           1   178.7     3.3    1.14   0.013
 106   6           1   222.0     3.3    1.40   0.013
 107   7           1   325.0     3.3    0.75   0.013
```

CARD GROUPS 16 TO 26 OMMITTED

CARD GROUP 27

```
    8
```

CARD GROUP 28 OMMITTED

CARD GROUP 29

```
    5    1    3
```

Proctor & Redfern Limited

Consulting Engineers

SHEET 3 OF 3

PROGRAM NAME

EO NO

CARD TYPE

DATE

CARD GROUP 30

1 2 3 4 5 6 7 8

CARD GROUPS 30 TO 47 OMMITTED

```
BRUCEWOOD - QUANTITY MODELING ONLY


 * * * * *  ELEMENT LINKAGES AND COMPUTATION SEQUENCE  * * * * *

 ELEMENT NO. ZERO IS GIVEN INTERNAL NO. = NO. ELEMENTS + 1 =  16

 EXTERNAL INTERNAL TYPE  DESCRIPTION      UPSTREAM ELEMENTS      ORDER OF COMPUTATIONS AT EACH TIME STEP (PROCEEDING DOWNSTREAM)
 ELEMENT  ELEMENT                          (EXTERNAL NOS.)                 COMPUTATION  EXTERNAL INTERNAL  INTERNAL UPSTREAM
 NUMBER   NUMBER                              1     2     3                SEQUENCE     NUMBER   NUMBER    ELEMENT NUMBERS

       1        1   16  MANHOLE               0     0     0                      1          1        1      16    16    16
       2        2   16  MANHOLE             101     0     0                      2        101        9       1    16    16
       3        3   16  MANHOLE             102     0     0                      3          2        2       9    16    16
       4        4   16  MANHOLE             103     0     0                      4        102       10       2    16    16
       5        5   16  MANHOLE             104     0     0                      5          3        3      10    16    16
       6        6   16  MANHOLE             105     0     0                      6        103       11       3    16    16
       7        7   16  MANHOLE             106     0     0                      7          4        4      11    16    16
       8        8   16  MANHOLE             107     0     0                      8        104       12       4    16    16
     101        9    1  CIRCULAR              1     0     0                      9          5        5      12    16    16
     102       10    1  CIRCULAR              2     0     0                     10        105       13       5    16    16
     103       11    1  CIRCULAR              3.    0     0                     11          6        6      13    16    16
     104       12    1  CIRCULAR              4     0     0                     12        106       14       6    16    16
     105       13    1  CIRCULAR              5     0     0                     13          7        7      14    16    16
     106       14    1  CIRCULAR              6     0     0                     14        107       15       7    16    16
     107       15    1  CIRCULAR              7     0     0                     15          8        8      15    16    16
```

```
BRUCEWOOD QUALITY SIMULATION WITH SWMM5


        NUMBER OF ELEMENTS =   15
        NUMBER OF TIME INT =   80
        TIME INTERVAL      = 300.0 SECONDS

 * * * * *  ELEMENT PARAMETERS  * * * * *

 EXT, TYPE  DESCRIPTION         SLOPE   DISTANCE  MANNING     GEOM1  GEOM2  GEOM3  NUMBER    AFULL    QFULL     QMAX      SUPER-CRITICAL
 ELE.                          (FT/FT)    (FT)    ROUGHNESS   (FT)   (FT)   (FT)     OF    (SQ.FT)   (CFS)     (CFS)     FLOW WHEN LESS
 NUM.                                                                              BARRELS                               THAN 95% FULL?
    1  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
    2  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
    3  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
    4  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
    5  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
    6  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
    7  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
    8  16    MANHOLE            0.0         0.0   0.0          0.0    0.0    0.0     1.0    0.0        0.0       0.0
  101   1    CIRCULAR           0.0033    278.1   0.0130       3.3    0.0    0.0     1.0    8.296     47.560    51.364       NO
  102   1    CIRCULAR           0.0043    238.8   0.0130       3.3    0.0    0.0     1.0    8.296     54.289    58.633       NO
  103   1    CIRCULAR           0.0051    108.7   0.0130       3.3    0.0    0.0     1.0    8.296     59.124    63.854       NO
  104   1    CIRCULAR           0.0048    296.1   0.0130       3.3    0.0    0.0     1.0    8.296     57.359    61.948       NO
  105   1    CIRCULAR           0.0114    178.7   0.0130       3.3    0.0    0.0     1.0    8.296     88.396    95.468       NO
  106   1    CIRCULAR           0.0140    222.0   0.0130       3.3    0.0    0.0     1.0    8.296     97.959   105.796       NO
  107   1    CIRCULAR           0.0075    325.0   0.0130       3.3    0.0    0.0     1.0    8.296     71.699    77.435       NO


  EPSILON = 0.000100     NO. OF ITERATIONS IN ROUTING ROUINE =     4



 HYDROGRAPHS AND POLLUTOGRAPHS PROVIDED TO SUBSEQUENT PROGRAMS FOR THE FOLLOWING ELEMENTS:

    8
 BRUCEWOOD QUALITY SIMULATION WITH SWMM5

TOTAL SIMULATION TIME = 24000.0 SECONDS. TIME STEP = 300.0 SECONDS.

INFLOW POLLUTOGRAPHS AND HYDROGRAPHS AT THE FOLLOWING EXTERNAL ELEMENT NUMBERS:

    5    1    3

                                        SELECTED INLET HYDROGRAPHS - CFS
EXTERNAL
ELEMENT    TIME STEP
NUMBER       1         2         3         4         5         6         7         8         9         10

    1        0.025     0.070     0.102     0.104     0.061     0.032     0.023     0.028     0.042     0.069
             0.123     0.210     0.314     0.381     0.501     0.705     0.780     0.668     0.554     0.529
             0.514     0.503     0.502     0.423     0.357     0.358     0.349     0.330     0.338     0.413
             0.563     0.646     0.547     0.398     0.374     0.367     0.274     0.166     0.112     0.083
             0.062     0.047     0.037     0.064     0.140     0.197     0.334     0.680     0.897     0.693
             0.419     0.493     0.862     1.240     1.294     1.124     1.020     1.297     1.897     2.037
             1.542     1.132     0.937     0.721     0.677     0.823     0.943     0.860     0.693     0.571
             0.454     0.312     0.183     0.121     0.090     0.065     0.049     0.038     0.031     0.025

    3        0.024     0.049     0.021     0.011     0.007     0.005     0.003     0.015     0.024     0.029
             0.052     0.087     0.093     0.085     0.147     0.192     0.162     0.149     0.143     0.139
             0.138     0.136     0.136     0.084     0.103     0.115     0.074     0.096     0.110     0.119
             0.182     0.159     0.095     0.111     0.120     0.076     0.053     0.039     0.029     0.023
             0.018     0.015     0.012     0.041     0.069     0.046     0.124     0.246     0.187     0.109
             0.120     0.183     0.288     0.345     0.301     0.285     0.277     0.418     0.566     0.462
             0.354     0.311     0.225     0.185     0.226     0.247     0.257     0.198     0.171     0.156
             0.095     0.064     0.046     0.034     0.026     0.021     0.017     0.014     0.012     0.010

    5        0.021     0.087     0.126     0.117     0.101     0.076     0.055     0.052     0.072     0.101
             0.162     0.286     0.432     0.528     0.696     0.968     1.079     1.009     0.911     0.840
             0.811     0.798     0.791     0.686     0.586     0.600     0.553     0.513     0.559     0.623
             0.811     0.958     0.833     0.679     0.648     0.580     0.449     0.329     0.234     0.171
             0.131     0.103     0.083     0.108     0.206     0.273     0.432     0.914     1.219     1.031
             0.784     0.814     1.218     1.752     1.930     1.791     1.655     1.947     2.754     3.039
             2.527     1.983     1.566     1.230     1.154     1.278     1.421     1.362     1.141     0.973
             0.774     0.547     0.378     0.262     0.190     0.144     0.113     0.090     0.073     0.061
```

```
                                        SELECTED OUTFLOW HYDROGRAPHS - CFS
EXTERNAL
ELEMENT    TIME STEP
NUMBER      1        2        3        4        5        6        7        8        9        10

  1       0.025    0.070    0.102    0.104    0.061    0.032    0.023    0.028    0.042    0.069
          0.123    0.210    0.314    0.381    0.501    0.705    0.780    0.668    0.554    0.529
          0.514    0.503    0.502    0.423    0.357    0.358    0.349    0.330    0.338    0.413
          0.563    0.646    0.547    0.398    0.374    0.367    0.274    0.166    0.112    0.083
          0.062    0.047    0.037    0.064    0.140    0.197    0.334    0.680    0.897    0.693
          0.419    0.493    0.862    1.240    1.294    1.124    1.020    1.297    1.897    2.037
          1.542    1.132    0.937    0.721    0.677    0.823    0.943    0.860    0.693    0.571
          0.454    0.312    0.183    0.121    0.090    0.065    0.049    0.038    0.031    0.025

  2       0.008    0.041    0.084    0.104    0.090    0.049    0.027    0.024    0.033    0.052
          0.088    0.155    0.259    0.366    0.449    0.626    0.777    0.714    0.592    0.529
          0.521    0.506    0.501    0.461    0.377    0.351    0.355    0.337    0.332    0.380
          0.502    0.625    0.601    0.452    0.368    0.373    0.317    0.222    0.142    0.099
          0.075    0.055    0.043    0.044    0.091    0.164    0.255    0.542    0.855    0.790
          0.512    0.428    0.719    1.148    1.310    1.181    1.039    1.180    1.742    2.058
          1.702    1.208    0.984    0.789    0.667    0.770    0.917    0.904    0.742    0.608
          0.498    0.366    0.240    0.157    0.107    0.080    0.058    0.045    0.035    0.028

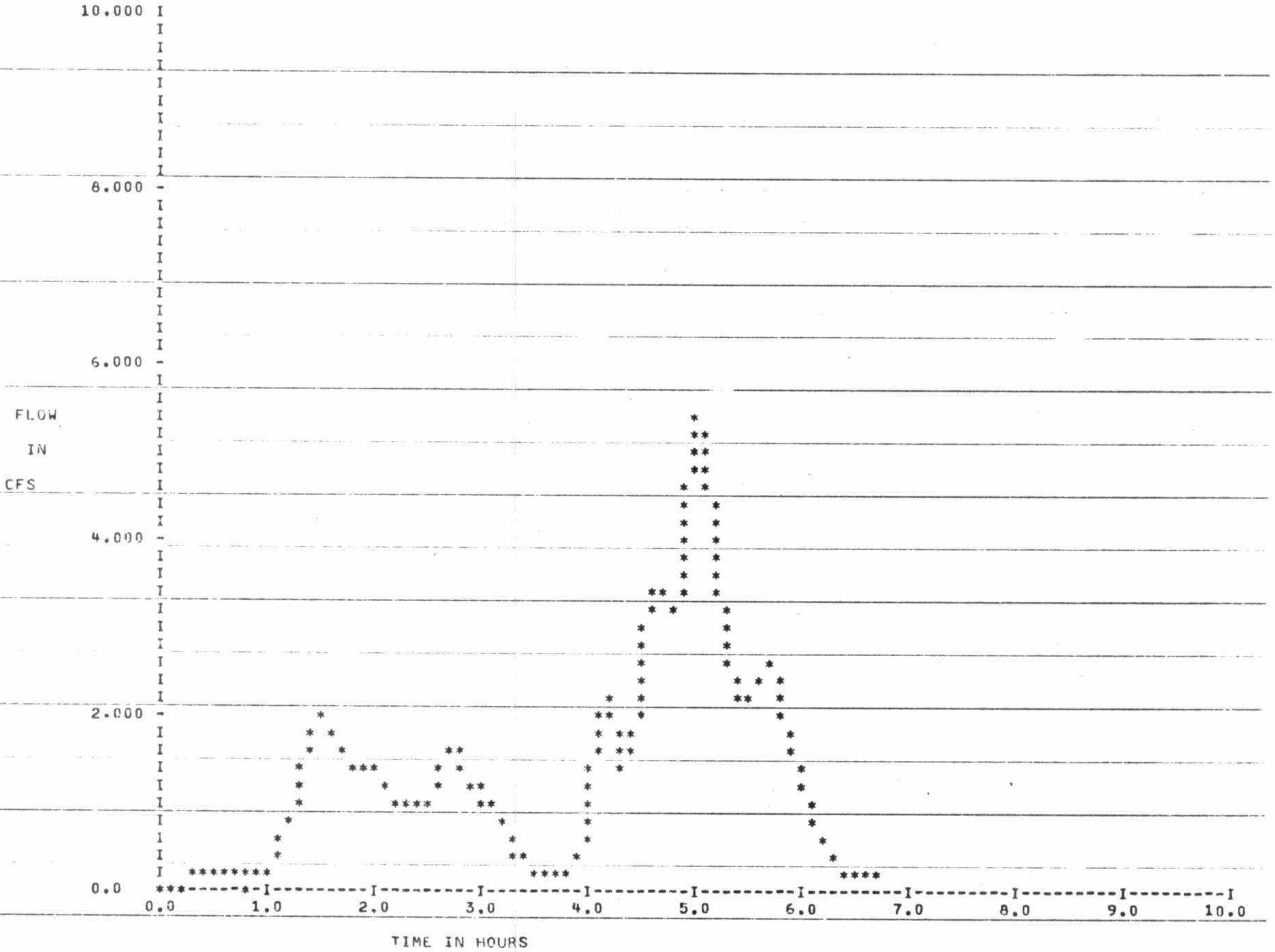
  3       0.027    0.072    0.085    0.109    0.107    0.075    0.037    0.038    0.051    0.071
          0.122    0.208    0.301    0.414    0.578    0.758    0.906    0.900    0.766    0.679
          0.657    0.649    0.636    0.562    0.506    0.465    0.428    0.440    0.441    0.481
          0.645    0.753    0.719    0.612    0.501    0.442    0.395    0.299    0.208    0.138
          0.103    0.079    0.060    0.083    0.134    0.175    0.336    0.681    0.971    0.953
          0.712    0.610    0.897    1.400    1.603    1.510    1.339    1.542    2.172    2.499
          2.167    1.606    1.237    1.022    0.916    0.966    1.150    1.117    0.962    0.794
          0.624    0.469    0.325    0.229    0.153    0.111    0.085    0.064    0.051    0.041

  4       0.019    0.063    0.086    0.101    0.111    0.082    0.045    0.034    0.050    0.066
          0.110    0.190    0.284    0.401    0.556    0.738    0.893    0.910    0.783    0.685
          0.657    0.650    0.637    0.574    0.509    0.471    0.431    0.436    0.443    0.472
          0.620    0.748    0.728    0.626    0.513    0.445    0.401    0.314    0.226    0.149
          0.108    0.084    0.063    0.074    0.123    0.168    0.294    0.641    0.946    0.972
          0.740    0.611    0.846    1.361    1.600    1.527    1.353    1.502    2.118    2.494
          2.211    1.650    1.261    1.039    0.921    0.955    1.130    1.134    0.973    0.813
          0.644    0.485    0.342    0.246    0.167    0.116    0.090    0.068    0.053    0.043

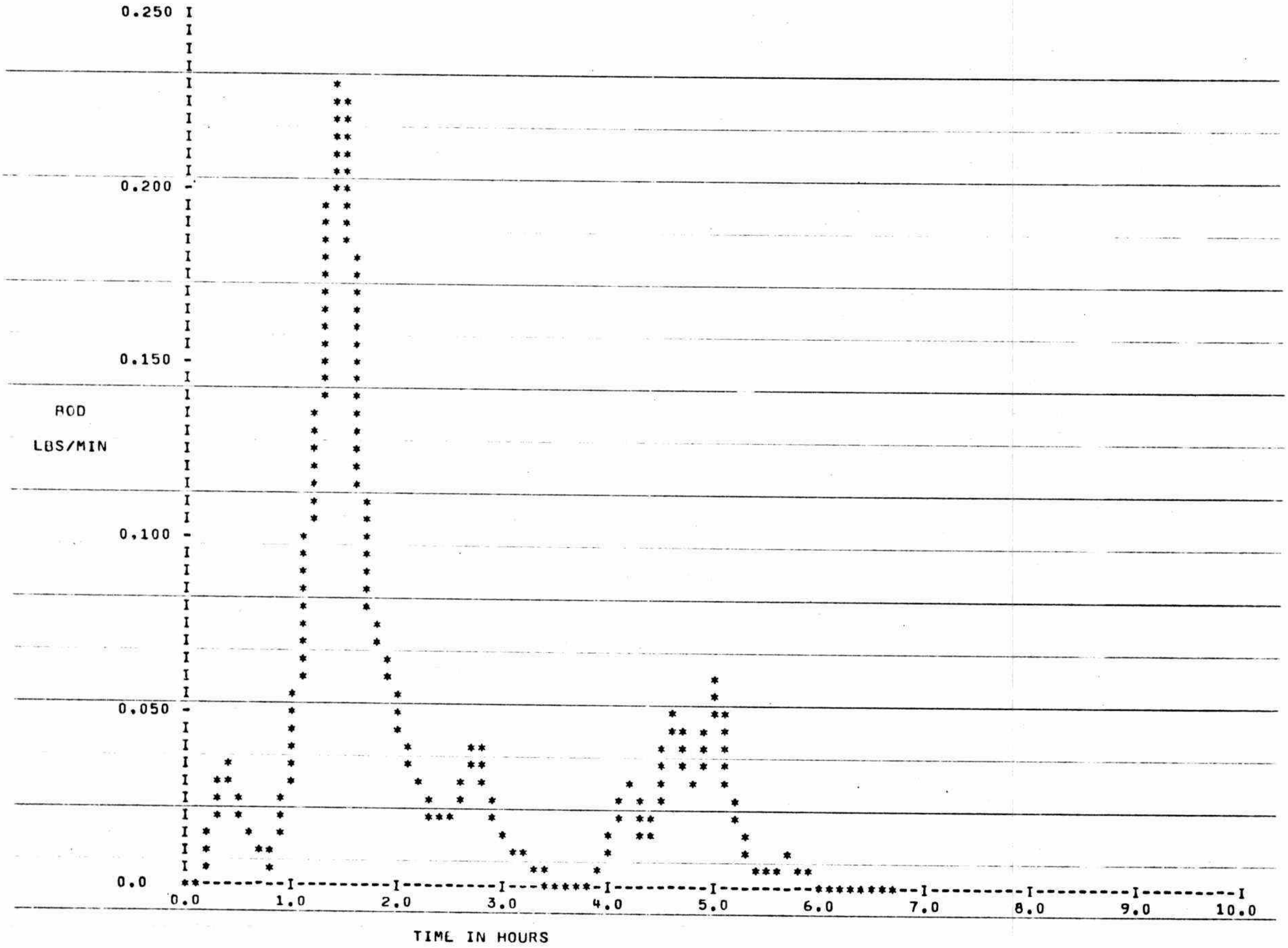
  5       0.028    0.124    0.202    0.210    0.207    0.178    0.120    0.089    0.111    0.158
          0.246    0.430    0.664    0.882    1.201    1.645    1.932    1.930    1.739    1.551
          1.471    1.451    1.433    1.287    1.114    1.080    0.999    0.941    1.002    1.083
          1.371    1.672    1.581    1.342    1.197    1.041    0.863    0.677    0.502    0.362
          0.257    0.199    0.157    0.173    0.300    0.418    0.652    1.416    2.090    2.025
          1.603    1.453    1.952    2.975    3.508    3.351    3.052    3.375    4.712    5.495
          4.840    3.762    2.897    2.317    2.095    2.212    2.499    2.518    2.163    1.822
          1.476    1.080    0.765    0.545    0.401    0.285    0.216    0.170    0.134    0.109

  6       0.019    0.098    0.190    0.213    0.206    0.188    0.134    0.092    0.103    0.147
          0.223    0.383    0.636    0.854    1.153    1.601    1.914    1.942    1.762    1.566
          1.474    1.452    1.435    1.309    1.133    1.075    1.018    0.941    0.990    1.074
          1.322    1.655    1.606    1.364    1.208    1.066    0.884    0.702    0.522    0.391
          0.277    0.208    0.166    0.164    0.265    0.398    0.608    1.292    2.061    2.055
          1.652    1.445    1.877    2.873    3.501    3.377    3.078    3.312    4.583    5.488
          4.924    3.843    2.961    2.357    2.104    2.187    2.473    2.532    2.205    1.850
          1.515    1.126    0.801    0.568    0.423    0.311    0.225    0.180    0.140    0.113
```

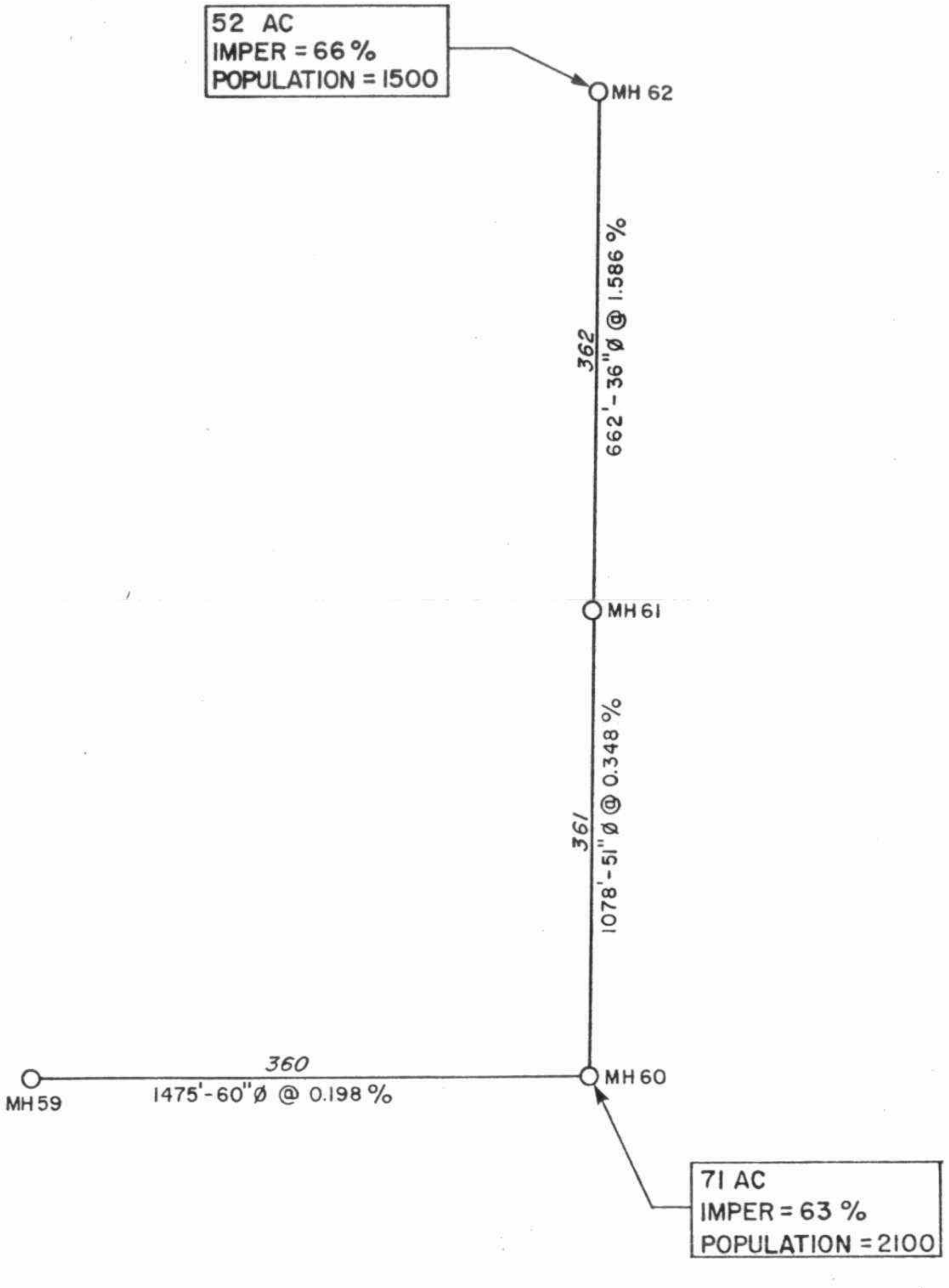
GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 8



GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 8



TRANSPORT
SAMPLE PROBLEM



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          TRANSPORT BLOCK  1976 SHORT COURSE SAMPLE

          NUMBER OF ELEMENTS =      7
          NUMBER OF TIME INT =  100
          TIME INTERVAL      = 300.0 SECONDS

 * * * * *  ELEMENT PARAMETERS  * * * * *

 EXT. TYPE  DESCRIPTION            SLOPE   DISTANCE  MANNING    GEOM1  GEOM2  GEOM3  NUMBER   AFULL    QFULL    QMAX     SUPER-CRITICAL
 ELE.                             (FT/FT)   (FT)    ROUGHNESS   (FT)   (FT)   (FT)    OF    (SQ.FT)   (CFS)    (CFS)    FLOW WHEN LESS
 NUM.                                                                               BARRELS                             THAN 95  FULL
   59  16    MANHOLE               0.0        0.0    0.0        0.0    0.0    0.0     1.0    0.0      0.0      0.0
   60  16    MANHOLE               0.0        0.0    0.0        0.0    0.0    0.0     1.0    0.0      0.0      0.0
   61  16    MANHOLE               0.0        0.0    0.0        0.0    0.0    0.0     1.0    0.0      0.0      0.0
   62  16    MANHOLE               0.0        0.0    0.0        0.0    0.0    0.0     1.0    0.0      0.0      0.0
  360   1    CIRCULAR              0.0020   662.0    0.0150     5.0    0.0    0.0     1.0   19.635  100.708  108.765      NO
  361   1    CIRCULAR              0.0038  1078.0    0.0150     4.3    0.0    0.0     1.0   14.186   90.924   98.198      NO
  362   1    CIRCULAR              0.0159  1475.0    0.0150     3.0    0.0    0.0     1.0    7.069   72.994   78.833      NO

 EPSILON = 0.000100      NO. OF ITERATIONS IN ROUTING ROUINE =     4


HYDROGRAPHS AND POLLUTOGRAPHS PROVIDED TO SUBSEQUENT PROGRAMS FOR THE FOLLOWING ELEMENTS

  59
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              TOTAL AREA INFILTRATION(IN GPM) DUE TO

      BASE FLOW      GROUND WATER          MELT          RAIN

        80.0000          0.0               0.0         125.0000



              APPORTIONED INFILTRATION

                                                           INFIL. INPUT AT
      ELEMENT NO.          QINFIL(CFS)        PROP. TOT. INFIL.  UPSTREAM ELE. NO.

         362                 0.164              0.3593              62
         361                 0.170              0.3720              61
         360                 0.123              0.2687              60



                        QUANTITY AND QUALITY OF  D W F  FOR EACH SUBAREA


      A1BOD   =     1300.00 LBS/DAY/CFS
      A1SS    =     1420.00 LBS/DAY/CFS
      A1COLI  =   2.00E 11 MPN/DAY PER CAPITA
      ADWF    =          0.56 CFS

KNUM INPUT     DWF  +  INFIL  =  QQDWF   KLAND  DWBOD       DWSS          TOTPOP  BODCONC    SSCONC     COLIFORMS
               CFS      CFS       CFS           LBS/MIN     LBS/MIN       PERSONS    MG/L      MG/L     MPN/100ML

  1   62     0.534    0.438     0.973     2       0.48        0.53

       TOTALS

             0.53     0.44      0.97              2.41 LBS  2.63 LBS     3690.     133.      145.      3.10E 07



ELEMENT FLOWS, AREAS, AND CONCENTRATIONS ARE INITIALIZED TO DRY WEATHER FLOW AND INFILTRATION VALUES.

                       FLOW       AREA       INIT. VEL.   BOD         S.S.       ECOLI.
ELE. NO.    TYPE      (CFS)    (SQ. FT.)     (FPS)      (LBS/CF)    (LBS/CF)   (MPN/ML)     CPOLL NO.4

  362         1       0.698     0.210       3.3265     0.0115      0.0126     1.22E 10
  361         1       0.868     0.421       2.0636     0.0093      0.0101     9.84E 09
  360         1       0.991     0.595       1.6649     0.0081      0.0089     8.62E 09
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```
INITIAL BED OF SOLIDS (LBS) IN SEWER DUE TO
   5.0 DAYS OF DRY WEATHER PRIOR TO STORM


   ELEMENT
   NUMBER                           SOLIDS IN
                                      BOTTOM
                                       (LBS)


     362                             0.07306
     361                             0.42297
     360                             3.53780





BED OF SOLIDS IN SEWER AT END OF STORM


   ELEMENT                          SOLIDS IN
   NUMBER                             BOTTOM
                                       (LBS)


     362                             0.00120
     361                             0.00704
     360                             0.09928
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           TRANSPORT BLOCK  1976 SHORT COURSE SAMPLE

TOTAL SIMULATION TIME = 30000.0 SECONDS. TIME STEP = 300.0 SECONDS.

INFLOW POLLUTOGRAPHS AND HYDROGRAPHS AT THE FOLLOWING EXTERNAL ELEMENT NUMBERS

  62    60


                                              SELECTED INLET HYDROGRAPHS - CFS
EXTERNAL
ELEMENT      TIME STEP
NUMBER          1           2           3           4           5           6           7           8           9          10

   62         0.371       3.246      12.273      26.241      40.092      51.871      58.447      53.112      39.120      24.265
             12.450       6.346       3.826       2.532       1.783       1.313       1.001       0.785       0.629       0.513
              0.425       0.357       0.303       0.260       0.225       0.197       0.173       0.153       0.136       0.122
              0.109       0.099       0.089       0.081       0.074       0.068       0.063       0.058       0.053       0.049
              0.046       0.042       0.040       0.037       0.035       0.032       0.030       0.029       0.027       0.025
              0.024       0.023       0.021       0.020       0.019       0.018       0.017       0.017       0.016       0.015
              0.014       0.014       0.013       0.013       0.012       0.012       0.011       0.011       0.010       0.010
              0.009       0.009       0.009       0.008       0.008       0.008       0.008       0.007       0.007       0.007
              0.007       0.006       0.006       0.006       0.006       0.006       0.005       0.005       0.005       0.005
              0.005       0.005       0.004       0.004       0.004       0.004       0.004       0.004       0.004       0.004

   60         0.446       3.990      15.200      32.849      50.844      66.477      75.506      69.264      51.604      32.473
             17.077       8.937       5.464       3.650       2.587       1.916       1.466       1.153       0.926       0.757
              0.629       0.529       0.450       0.387       0.335       0.293       0.258       0.228       0.203       0.182
              0.163       0.148       0.134       0.122       0.111       0.102       0.094       0.086       0.080       0.074
              0.069       0.064       0.059       0.056       0.052       0.049       0.046       0.043       0.040       0.038
              0.036       0.034       0.032       0.031       0.029       0.028       0.026       0.025       0.024       0.023
              0.022       0.021       0.020       0.019       0.018       0.017       0.017       0.016       0.015       0.015
              0.014       0.014       0.013       0.013       0.012       0.012       0.011       0.011       0.011       0.010
              0.010       0.010       0.009       0.009       0.009       0.008       0.008       0.008       0.008       0.007
              0.007       0.007       0.007       0.007       0.006       0.006       0.006       0.006       0.006       0.006
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                                        SELECTED INLET POLLUTOGRAPHS
EXTERNAL
ELEMENT    TIME STEP
NUMBER        1          2          3          4          5          6          7          8          9          10

                                        *** BOD IN LBS/MIN ***

  62        0.177      0.263      1.582      2.031      2.746      2.552      1.924      1.161      0.598      0.197
            0.053      0.016      0.007      0.004      0.003      0.002      0.001      0.001      0.001      0.001
            0.001      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.0
            0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0

                                    ** SUSPENDED SOLIDS IN LBS/MIN **

  62        0.087      0.661      6.697     27.615     49.528     45.894     34.607     20.889     10.951      3.532
            0.067      0.252      0.106      0.056      0.033      0.022      0.015      0.011      0.009      0.007
            0.006      0.005      0.004      0.003      0.003      0.002      0.002      0.002      0.002      0.001
            0.001      0.001      0.001      0.001      0.001      0.001      0.001      0.001      0.001      0.001
            0.001      0.001      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.0
            0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0

                                      *** COLIFORM IN MPN/MIN ***

  62     1.52E 09   6.57E 09   2.35E 10   4.36E 10   5.24E 10   4.86E 10   3.66E 10   2.21E 10   1.16E 10   5.69E 09
         2.55E 09   1.21E 09   7.05E 08   4.56E 08   3.16E 08   2.30E 08   1.74E 08   1.35E 08   1.08E 08   8.77E 07
         7.24E 07   6.07E 07   5.14E 07   4.40E 07   3.81E 07   3.32E 07   2.91E 07   2.57E 07   2.29E 07   2.04E 07
         1.63E 07   1.65E 07   1.50E 07   1.36E 07   1.24E 07   1.14E 07   1.04E 07   9.61E 06   8.88E 06   8.21E 06
         7.62E 06   7.08E 06   6.60E 06   6.16E 06   5.76E 06   5.40E 06   5.06E 06   4.76E 06   4.48E 06   4.22E 06
         3.99E 06   3.77E 06   3.57E 06   3.38E 06   3.21E 06   3.04E 06   2.89E 06   2.75E 06   2.62E 06   2.50E 06
         2.38E 06   2.28E 06   2.18E 06   2.08E 06   1.99E 06   1.91E 06   1.83E 06   1.76E 06   1.69E 06   1.62E 06
         1.56E 06   1.50E 06   1.44E 06   1.39E 06   1.34E 06   1.29E 06   1.24E 06   1.20E 06   1.16E 06   1.12E 06
         1.08E 06   1.05E 06   1.01E 06   9.82E 05   9.49E 05   9.18E 05   8.90E 05   8.63E 05   8.37E 05   0.0
         0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0        0.0

                                        *** BOD IN LBS/MIN ***

  60        0.216      0.850      2.210      2.903      4.023      3.798      2.969      1.844      0.974      0.323
            0.070      0.029      0.014      0.008      0.005      0.003      0.002      0.002      0.001      0.001
            0.001      0.001      0.001      0.001      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000
            0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000

                                    ** SUSPENDED SOLIDS IN LBS/MIN **
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60          0.113     0.842     0.378    35.258    71.598    68.528    53.304    33.151    17.825     5.754
            1.521     0.453     0.194     0.102     0.062     0.041     0.029     0.021     0.016     0.013
            0.010     0.009     0.007     0.006     0.005     0.005     0.004     0.003     0.003     0.003
            0.002     0.002     0.002     0.002     0.002     0.002     0.001     0.001     0.001     0.001
            0.001     0.001     0.001     0.001     0.001     0.001     0.001     0.001     0.001     0.001
            0.001     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
            0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
            0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
            0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
            0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000

                                   *** COLIFORM IN MPN/MIN ***

60        2.02E 09  6.88E 09  3.22E 10  5.12E 10  7.58E 10  7.26E 10  5.64E 10  3.51E 10  1.89E 10  9.46E 09
          4.35E 09  2.12E 09  1.25E 09  8.15E 08  5.68E 08  4.16E 08  3.15E 08  2.46E 08  1.97E 08  1.60E 08
          1.32E 08  1.11E 08  9.42E 07  8.08E 07  6.99E 07  6.10E 07  5.35E 07  4.73E 07  4.21E 07  3.76E 07
          3.38E 07  3.05E 07  2.76E 07  2.51E 07  2.30E 07  2.10E 07  1.93E 07  1.78E 07  1.64E 07  1.52E 07
          1.41E 07  1.31E 07  1.22E 07  1.14E 07  1.07E 07  1.00E 07  9.38E 06  8.82E 06  8.31E 06  7.83E 06
          7.39E 06  6.99E 06  6.61E 06  6.27E 06  5.95E 06  5.65E 06  5.37E 06  5.11E 06  4.87E 06  4.64E 06
          4.43E 06  4.23E 06  4.04E 06  3.87E 06  3.70E 06  3.55E 06  3.40E 06  3.27E 06  3.14E 06  3.01E 06
          2.90E 06  2.78E 06  2.68E 06  2.58E 06  2.49E 06  2.40E 06  2.32E 06  2.23E 06  2.16E 06  2.08E 06
          2.01E 06  1.95E 06  1.89E 06  1.82E 06  1.76E 06  1.71E 06  1.66E 06  1.61E 06  1.56E 06  1.51E 06
          1.47E 06  1.42E 06  1.38E 06  1.34E 06  1.31E 06  1.27E 06  1.24E 06  1.20E 06  1.17E 06  1.14E 06
```

```
                                   SELECTED OUTFLOW HYDROGRAPHS - CFS
EXTERNAL
ELEMENT      TIME STEP
NUMBER          1         2         3         4         5         6         7         8         9        10

   61         0.674     1.641     7.643    21.012    36.145    48.849    57.559    57.060    45.466    30.455
             17.854     9.621     5.664     4.142     3.127     2.511     2.100     1.831     1.628     1.478
              1.367     1.282     1.222     1.173     1.132     1.097     1.066     1.043     1.023     1.006
              0.991     0.977     0.968     0.959     0.950     0.943     0.937     0.931     0.926     0.922
              0.918     0.914     0.911     0.908     0.906     0.903     0.901     0.899     0.897     0.895
              0.894     0.892     0.891     0.890     0.889     0.888     0.887     0.886     0.885     0.884
              0.883     0.883     0.882     0.881     0.881     0.880     0.880     0.879     0.879     0.879
              0.878     0.878     0.877     0.877     0.877     0.876     0.876     0.876     0.876     0.875
              0.875     0.875     0.875     0.874     0.874     0.874     0.874     0.874     0.874     0.873
              0.873     0.873     0.873     0.873     0.873     0.873     0.872     0.872     0.872     0.872

   60         1.439     5.062    18.291    45.684    80.062   110.280   100.708   100.708   100.708   100.708
             67.852    22.604    13.531     9.068     6.612     5.064     4.057     3.370     2.882     2.510
              2.232     2.020     1.864     1.745     1.644     1.559     1.487     1.426     1.376     1.333
              1.297     1.266     1.239     1.215     1.195     1.177     1.162     1.148     1.135     1.124
              1.114     1.105     1.097     1.090     1.084     1.078     1.072     1.067     1.063     1.058
              1.055     1.051     1.048     1.045     1.042     1.039     1.037     1.035     1.033     1.031
              1.029     1.027     1.025     1.024     1.023     1.021     1.020     1.019     1.018     1.017
              1.016     1.015     1.014     1.013     1.012     1.011     1.011     1.010     1.009     1.009
              1.008     1.007     1.007     1.006     1.006     1.005     1.005     1.005     1.004     1.004
              1.003     1.003     1.003     1.002     1.002     1.002     1.001     1.001     1.001     1.001

   59         1.040     2.536    11.394    35.474    69.842   101.959   100.023   100.931   100.632   100.733
             86.616    35.506    14.271    11.424     7.583     5.887     4.607     3.778     3.194     2.751
              2.431     2.179     1.981     1.834     1.720     1.623     1.541     1.472     1.419     1.375
              1.332     1.296     1.265     1.238     1.215     1.195     1.177     1.161     1.147     1.135
              1.124     1.114     1.105     1.097     1.090     1.084     1.078     1.072     1.067     1.063
              1.058     1.055     1.051     1.048     1.045     1.042     1.039     1.037     1.035     1.033
              1.031     1.029     1.027     1.025     1.024     1.022     1.021     1.020     1.019     1.018
              1.017     1.016     1.015     1.014     1.013     1.012     1.011     1.011     1.010     1.009
              1.009     1.008     1.007     1.007     1.006     1.006     1.005     1.005     1.005     1.004
              1.004     1.003     1.003     1.003     1.002     1.002     1.002     1.001     1.001     1.001
```

```
                                        SELECTED OUTFLOW POLLUTOGRAPHS
EXTERNAL
ELEMENT    TIME STEP
NUMBER        1          2          3          4          5          6          7          8          9          10

                                       *** BOD IN LBS/MIN ***

  61        0.471      0.675      1.688      2.697      3.155      3.269      2.761      2.002      1.293      0.818
            0.567      0.470      0.446      0.448      0.447      0.450      0.451      0.457      0.458      0.460
            0.462      0.463      0.467      0.471      0.473      0.475      0.475      0.476      0.477      0.478
            0.478      0.479      0.479      0.479      0.480      0.480      0.480      0.480      0.480      0.481
            0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481
            0.481      0.481      0.481      0.482      0.482      0.482      0.482      0.482      0.482      0.482
            0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482
            0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482
            0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482
            0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482      0.482

                                       ** SUSPENDED SOLIDS IN LBS/MIN **

  61        0.494      0.711      3.546     17.313     40.934     50.371     41.332     27.768     15.314      6.944
            2.448      1.023      0.673      0.579      0.539      0.522      0.514      0.514      0.512      0.511
            0.511      0.512      0.515      0.519      0.521      0.521      0.522      0.523      0.523      0.524
            0.524      0.524      0.525      0.525      0.525      0.525      0.526      0.526      0.526      0.526
            0.526      0.526      0.526      0.526      0.526      0.526      0.527      0.527      0.527      0.527
            0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527
            0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527
            0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527
            0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527
            0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527

                                       *** COLIFORM IN MPN/MIN ***

  61     4.58E 11   5.06E 11   7.76E 11   7.82E 11   6.43E 11   5.88E 11   5.67E 11   5.48E 11   5.22E 11   5.02E 11
         4.89E 11   4.67E 11   4.61E 11   4.69E 11   4.72E 11   4.76E 11   4.78E 11   4.84E 11   4.86E 11   4.88E 11
         4.90E 11   4.92E 11   4.97E 11   5.01E 11   5.03E 11   5.04E 11   5.05E 11   5.06E 11   5.07E 11   5.08E 11
         5.08E 11   5.09E 11   5.09E 11   5.10E 11   5.10E 11   5.10E 11   5.10E 11   5.11E 11   5.11E 11   5.11E 11
         5.11E 11   5.11E 11   5.11E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
         5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
         5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
         5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
         5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
         5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11

                                       *** BOD IN LBS/MIN ***

  60        0.671      1.289      3.072      5.176      7.372      7.287      3.880      4.172      3.432      2.950
            0.758      0.531      0.425      0.417      0.405      0.417      0.409      0.427      0.422      0.437
            0.428      0.444      0.438      0.459      0.452      0.468      0.459      0.473      0.462      0.476
            0.465      0.479      0.468      0.481      0.469      0.482      0.471      0.483      0.472      0.484
            0.472      0.485      0.473      0.485      0.473      0.486      0.474      0.486      0.474      0.486
            0.474      0.486      0.474      0.487      0.475      0.487      0.475      0.487      0.475      0.487
            0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487
            0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487
            0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487
            0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487      0.475      0.487

                                       ** SUSPENDED SOLIDS IN LBS/MIN **
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```
60        0.645      1.331      9.697     43.669     99.663    115.098     63.866     67.785     53.844     42.221
          3.518      5.094      0.0        1.847      0.0        1.153      0.0        1.021      0.0        0.995
          0.0        0.988      0.005      1.000      0.017      1.007      0.022      1.010      0.024      1.013
          0.027      1.015      0.028      1.016      0.030      1.017      0.031      1.018      0.031      1.019
          0.032      1.019      0.032      1.019      0.032      1.020      0.033      1.020      0.033      1.020
          0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020
          0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020
          0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020
          0.033      1.021      0.033      1.020      0.033      1.021      0.033      1.020      0.033      1.020
          0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020      0.033      1.020

                                      *** COLIFORM IN MPN/MIN ***

60      4.96E 11   4.21E 11   6.29E 11   1.12E 12   1.08E 12   7.98E 11   4.22E 11   5.19E 11   5.66E 11   7.49E 11
        6.35E 11   2.85E 11   5.76E 11   2.55E 11   5.86E 11   2.70E 11   5.97E 11   2.84E 11   6.13E 11   2.96E 11
        6.20E 11   3.04E 11   6.32E 11   3.20E 11   6.48E 11   3.31E 11   6.55E 11   3.36E 11   6.59E 11   3.40E 11
        6.62E 11   3.42E 11   6.65E 11   3.45E 11   6.67E 11   3.46E 11   6.68E 11   3.47E 11   6.69E 11   3.48E 11
        6.70E 11   3.49E 11   6.71E 11   3.50E 11   6.71E 11   3.50E 11   6.71E 11   3.50E 11   6.72E 11   3.51E 11
        6.72E 11   3.51E 11   6.72E 11   3.51E 11   6.72E 11   3.51E 11   6.72E 11   3.51E 11   6.72E 11   3.51E 11
        6.73E 11   3.51E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11
        6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11
        6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11
        6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11   6.73E 11   3.52E 11

                                      *** BOD IN LBS/MIN ***

59        0.494      0.844      2.314      4.736      6.937      7.657      4.946      3.937      3.784      3.128
          1.840      0.394      0.402      0.418      0.378      0.389      0.389      0.395      0.402      0.407
          0.414      0.418      0.423      0.431      0.439      0.445      0.450      0.453      0.458      0.462
          0.464      0.465      0.468      0.469      0.471      0.472      0.473      0.474      0.475      0.475
          0.476      0.476      0.477      0.477      0.478      0.478      0.478      0.478      0.479      0.479
          0.479      0.479      0.479      0.479      0.479      0.480      0.480      0.480      0.480      0.480
          0.480      0.480      0.480      0.480      0.480      0.480      0.480      0.480      0.480      0.480
          0.480      0.480      0.480      0.480      0.480      0.481      0.481      0.481      0.481      0.481
          0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481
          0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481      0.481

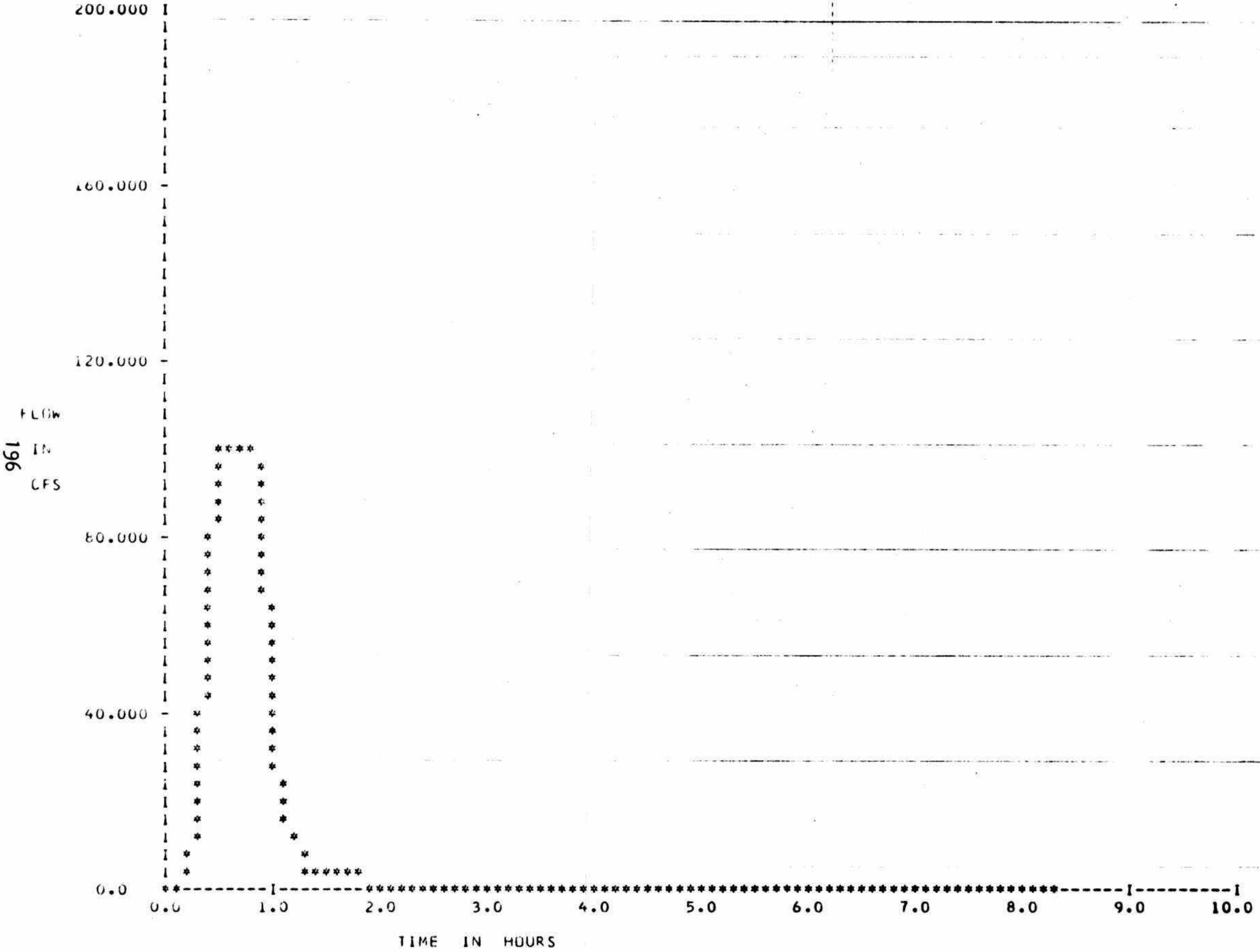
                                      ** SUSPENDED SOLIDS IN LBS/MIN **

59        0.667      1.141      5.269     28.487     79.937    115.042     80.518     64.430     60.384     46.733
         21.773      1.001      2.237      1.037      0.858      0.598      0.553      0.500      0.491      0.479
          0.480      0.478      0.479      0.484      0.491      0.496      0.500      0.502      0.507      0.511
          0.513      0.514      0.516      0.517      0.518      0.519      0.520      0.521      0.522      0.522
          0.523      0.523      0.524      0.524      0.524      0.525      0.525      0.525      0.525      0.525
          0.526      0.526      0.526      0.526      0.526      0.526      0.526      0.526      0.526      0.526
          0.526      0.526      0.526      0.527      0.526      0.527      0.527      0.527      0.527      0.527
          0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527
          0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527
          0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527      0.527

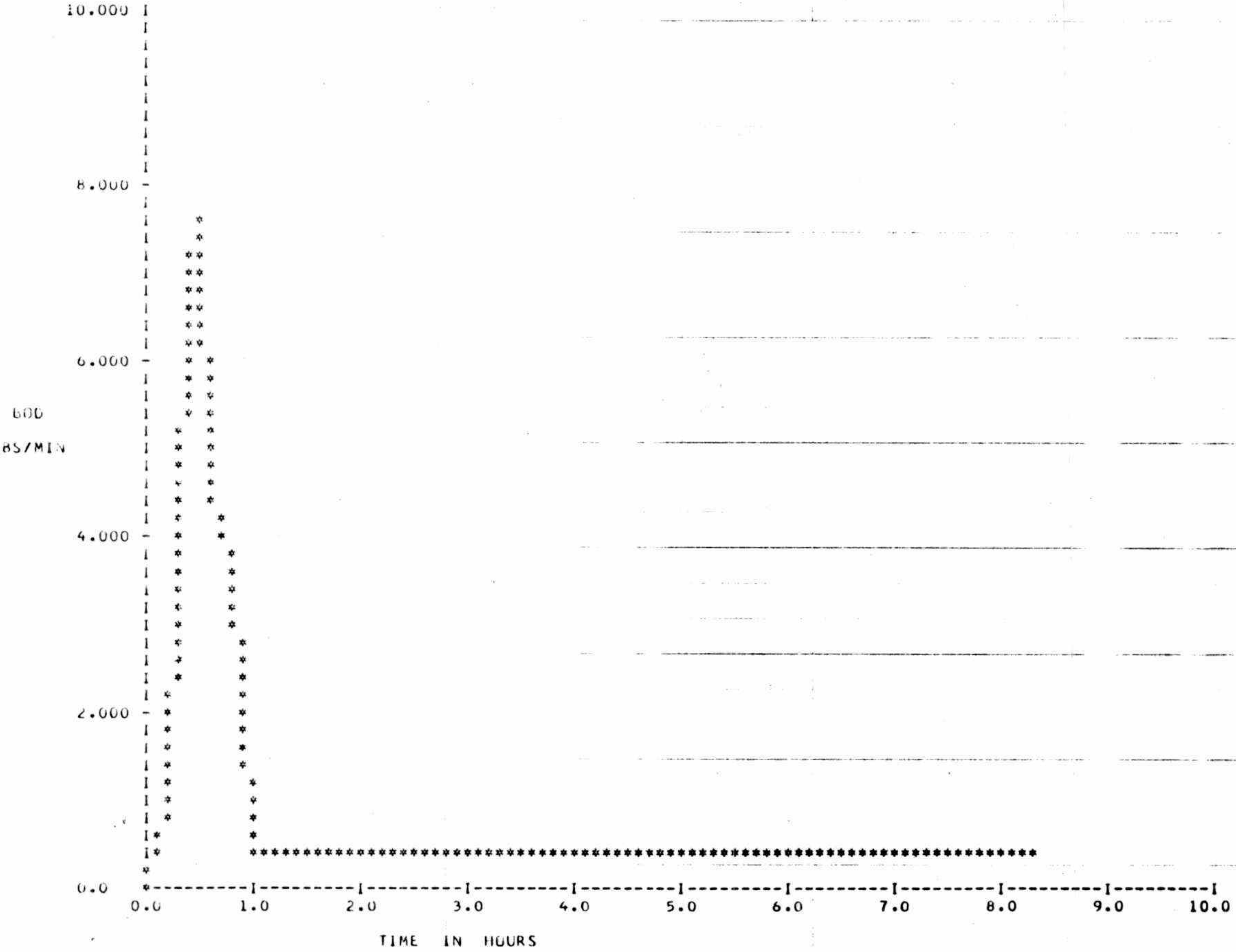
                                      *** COLIFORM IN MPN/MIN ***

59      4.66E 11   5.26E 11   7.57E 11   1.06E 12   1.21E 12   9.39E 11   5.24E 11   4.66E 11   5.50E 11   6.69E 11
        7.44E 11   3.80E 11   3.00E 11   4.10E 11   3.86E 11   4.04E 11   4.07E 11   4.16E 11   4.25E 11   4.31E 11
        4.38E 11   4.44E 11   4.49E 11   4.58E 11   4.67E 11   4.73E 11   4.78E 11   4.82E 11   4.88E 11   4.92E 11
        4.94E 11   4.96E 11   4.98E 11   5.00E 11   5.01E 11   5.03E 11   5.04E 11   5.05E 11   5.05E 11   5.06E 11
        5.07E 11   5.07E 11   5.08E 11   5.08E 11   5.09E 11   5.09E 11   5.09E 11   5.10E 11   5.10E 11   5.10E 11
        5.10E 11   5.11E 11   5.11E 11   5.11E 11   5.11E 11   5.11E 11   5.11E 11   5.11E 11   5.11E 11   5.11E 11
        5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
        5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
        5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11   5.12E 11
```

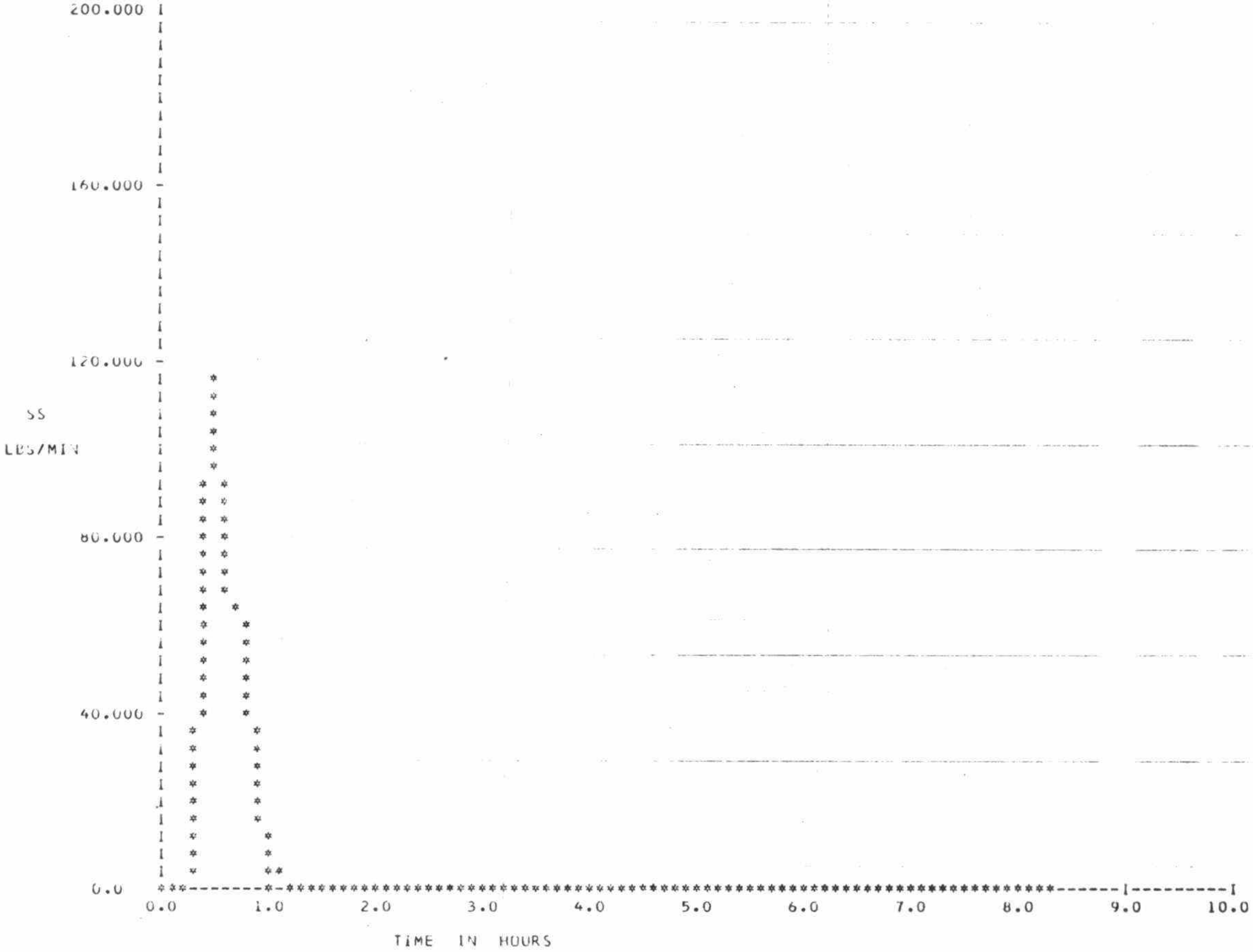
OUTPUT FROM TRANSPORT BLOCK 1976 SHORT COURSE SAMPLE 59



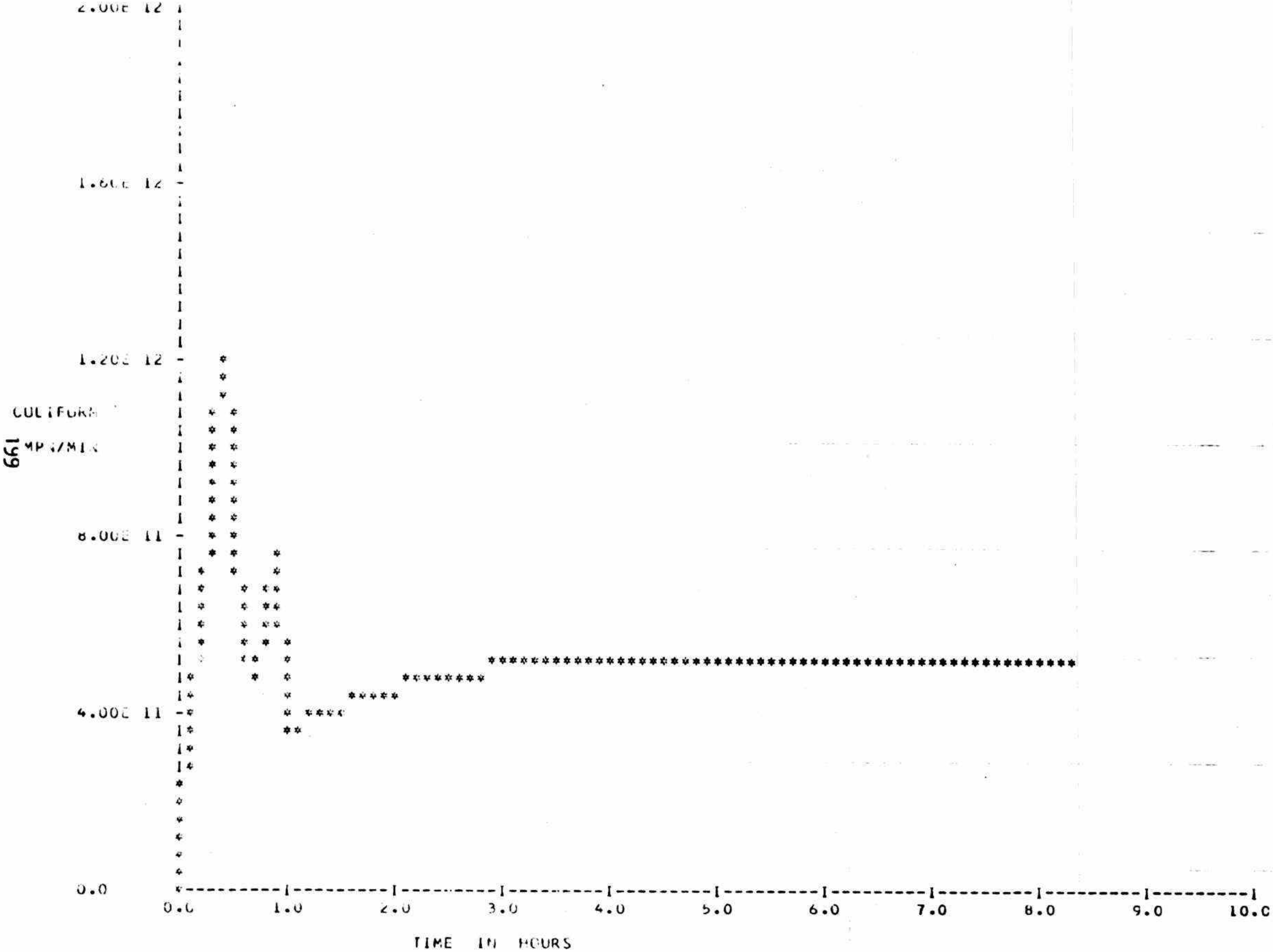
OUTPUT FROM TRANSPORT BLOCK 1976 SHORT COURSE SAMPLE



OUTPUT FROM TRANSPORT BLOCK 1976 SHORT COURSE SAMPLE



OUTPUT FROM TRANSPORT BLOCK 1976 SHORT COURSE SAMPLE



LUMPING WORKSHOP

LUMPING DEMONSTRATION - BRUCEWOOD

A. Model only pipes > 36", two subcatchments.

1) Subcatchment width, and imperviousness

(a) Lumping from detailed model

AREA 2

Subcatchment #	% Imp	L	Area (Acres)	Width (ft)
1	64	110	2.22	879
2	53	120	3.32	1205
3	58	110	1.58	626
4	61	110	3.06	1212
5	0	-	0.56	70
6	0	-	0.58	45
8	56	90	1.47	711
9	58	105	3.83	1589
10	0	-	0.87	50
12	74	105	2.80	1162
13	59	130	2.77	928
14	71	110	3.52	1394
15	67	100	1.08	470
	57.62	116.5	27.66	10341

AREA 1

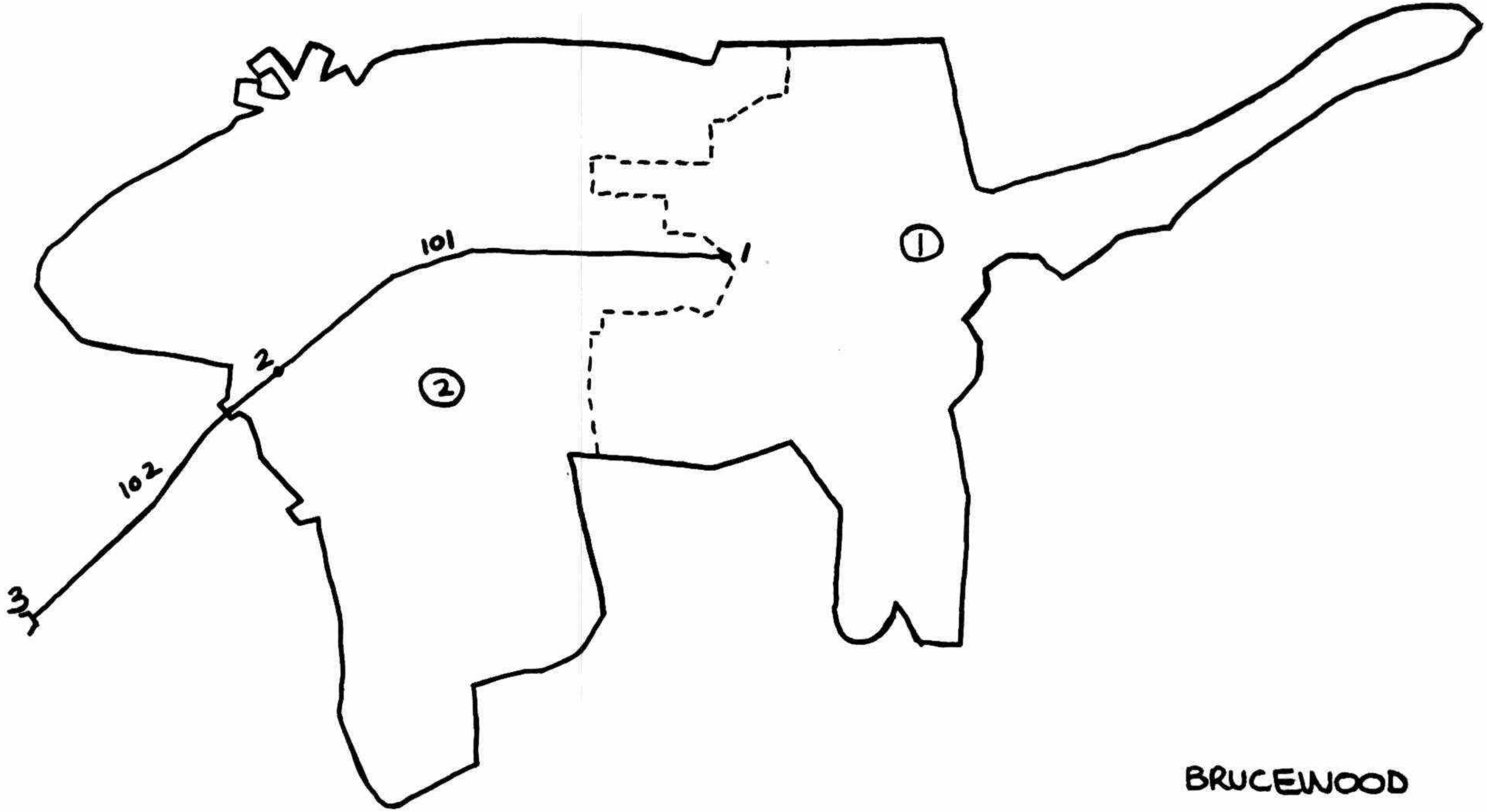
Subcatchment #	% Imp	L	Area (Acres)	Width (ft)
7	0	-	0.50	60
11	27	85	1.57	805
16	50	160	2.55	694
17	27	70	4.38	2726
18	40	35	1.19	1481
19	27	125	3.68	1282
20	52	130	3.10	1039
21	40	120	3.60	1307
	35.99	92.7	20.57	9664

(b) Lumping from original data

Subcatchment widths

AREA 2 Avg L = 110' (estimated)
Avg W = 10953'

AREA 1 Avg L = 100' (estimated)
Avg W = 8960'



BRUCEWOOD
LUMPED SCHEMATIC

Imperviousness:

AREA 1	streets	1940' x 26' street	=	50,440	
	streets	1700' x 50' street	=	85,000	
	roofs	54 x 2500 sq. ft.	=	135,000	
	driveways	54 x 20' x 50'	=	54,000	
	% imp. = 36.21			324,440	sq. ft.
				7.45	acres
AREA 2	streets	4800' x 26'	=	124,800	
	roofs	157 x 2400 sq. ft.	=	376,800	
	driveways	157 x 20' x 20'	=	125,600	
				627,200	sq. ft
	% imp. = 52.05			14.40	acres

2) Gutter Lengths and Sizes

Define "representative" length of flow path in each subarea,

	Area 1	Area 2
max. flow path lengths to inlet	1,500	1,700
	800	1,300
	710	3,000
	840	avg 1500
	3,850	
	avg 962	

Representative length is approx. 1/2 to 2/3 of average maximum length.

∴ length of gutters: AREA 1 = 620,

AREA 2 = 1000,

gutter capacity = capacity of outlet pipes:

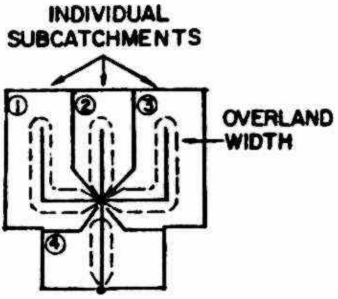
AREA 1 - 39" @ .33%

AREA 2 - 39" @ 1.14%

NOTE: This procedure for gutter modelling does not account for time offset of overland flow inflow hydrographs.

SCHEMATIC ILLUSTRATION OF METHODS OF LUMPING

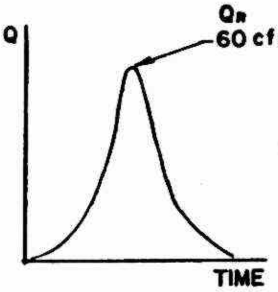
CASE I
FINE
DISCRETIZATION
4 SUBCATCHMENTS



WIDTH I = 2000 FT.
" 2 = 1500 "
" 3 = 2000 "
" 4 = 1500 "

RUNOFF BLOCK RESULTS

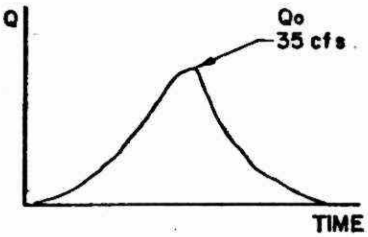
SUM OF 4 OVERLAND
FLOW HYDROGRAPH



(A)

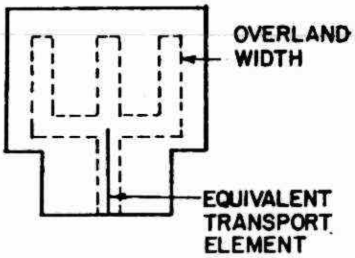
TRANSPORT BLOCK RESULTS

OUTLET HYDROGRAPH
AFTER CONDUIT ROUTING



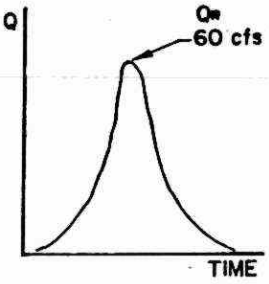
(B)

CASE 2
LUMPED
CATCHMENT
WITH WIDTH
SUMMATED



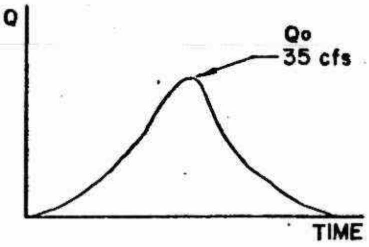
WIDTH = 7000 FT.

OVERLAND FLOW HYDROGRAPH
FROM SINGLE SUBCATCHMENT



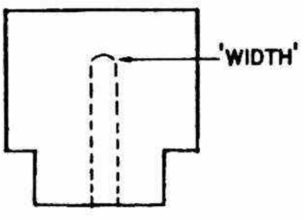
(A)

OUTLET HYDROGRAPH
AFTER CONDUIT ROUTING



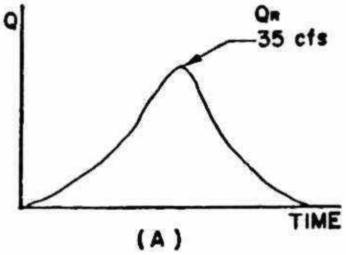
(B)

CASE 3
LUMPED I
CATCHMENT
WITH REDUCED
'WIDTH'



WIDTH = 3000 FT.

OVERLAND FLOW HYDROGRAPH
FROM SINGLE SUBCATCHMENT



(A)

3) Curb Length and Catch Basins

Curb Length for Subcatchment No. 1

Subcatchment No.	Curb length in 10^2ft	Catch Basins
7	1.7	1
11	4.4	4
16	7.8	1
17	23.05	12
18	8.8	6
19	7.2	2
20	8.8	6
21	8.4	4
	70.15	36

Curb Length for Subcatchment No. 2

Subcatchment No.	Curb length in 10^2ft	Catch Basins
1	8.40	2
2	11.15	3
3	5.35	5
4	10.85	2
5	.10	1
6	.10	1
8	6.00	2
9	14.50	6
10	0.10	1
12	11.40	3
13	10.55	3
14	15.00	7
15	5.40	3
	98.90	39

4) TRANSPORT Data

ELEMENT	LENGTH	SLOPE	DIA.
101	278.1	.33%	3.25'
	238.8	.43%	3.25'
	108.7	.51%	3.25'
	296.1	.48%	3.25'
	921.7		

$$\text{Avg. Slope} = \frac{278.1 \times .33 + 238.8 \times .43 + 108.7 \times .51 + 296.1 \times .48}{921.7}$$

$$= \frac{91.773 + 102.684 + 55.437 + 142.128}{921.7}$$

$$= \frac{392.022}{921.7} = 0.425\%$$

ELEMENT	LENGTH	SLOPE	DIA.
102	178.7	1.14%	3.25'
	222.0	1.40%	3.25'
	325.0	0.75%	3.25'
	725.7		

$$\text{Avg. Slope} = \frac{178.7 \times 1.14 + 222 \times 1.4 + 325 \times .75}{725.7}$$

$$= \frac{203.718 + 310.8 + 243.75}{725.7} = \frac{758.268}{725.7}$$

$$= 1.0448$$

B. Model as one subcatchment using the RUNOFF Block alone, without gutters or pipes.

WIDTH = 2 x length of main drainage conduit
= 4000'

% IMPERVIOUSNESS = 48.39%

CURB LENGTH = 169.05 ft

CATCH BASINS = 75

LUMPING WORKSHOP EXAMPLE

Prepare input coding for card types for the RUNOFF workshop example assuming that the whole area is to be modelled as one subcatchment draining to the INLET with a single gutter.

JAMES F. MacLAREN LTD.

GENERAL PURPOSE DATA FORM

2 - SUBCATCHMENTS

SPECIAL KEYPUNCH INSTRUCTIONS: SWMM WORKSHOP / BRUCEWOOD LUMPING DEMO.

SUBMITTED BY B Clarke

JOB NUMBER 10680

PAGE NO. 1

CARD GROUP	1 2 3 4 5	6 7 8 9 10	11 12 13 14 15	16 17 18 19 20	21 22 23 24 25	26 27 28 29 30	31 32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48 49 50	51 52 53 54 55	56 57 58 59 60	61 62 63 64 65	66 67 68 69 70	71 72 73 74 75	76 77 78 79 80
1	SWMM WORKSHOP - BRUCEWOOD LUMPING DEMONSTRATION															
	STORM OF AUG 29 1975 - 2 SUBCATCHMENTS, 39 IN. PIPE ONLY															
2	2	80	0 0	5.	1	25.	0	0	0							
3	70	5.														
4	.24	.0	.0	.0	.0	.0	.0	.12	.0	.12						
	.12	.24	.0	.12	.12	.12	.0	.12	.0	.12						
	.0	.12	.0	.0	.12	.0	.0	.12	.0	.12						
	.12	.0	.0	.12	.0	.0	.0	.0	.0	.0						
	.0	.0	.0	.12	.0	.0	.24	.12	.0	.0						
	.12	.12	.24	.12	.12	.12	.12	.36	.24	.12						
	.12	.12	.0	.12	.12	.12	.12	.0	.12	.0						
5		10	1	2	3.25		620.		.0033					.013		
		20	2	2	3.25		1000.		.0114					.013		
6																
7	1	1	10	3960.	20.57	36.2	.09	.013	.25	.062	.184	3.	.52		.00115	
	1	2	20	10953	27.66	52.1	.025	.013	.25	.062	.184	3.	.52		.00115	
8																
9		1		2		14		1		20.		60.	1	2		
9A		0.7		2.3		3.3		4.6		1.5						
9B		10														
9C		100.		100.		100.		100.		100	SET-S					
		1000.		1000.		1000.		1000.		1000.	SUS-S					
		.13E 7		.27E 7		.17E 7		.1E 7		0	COLIF					
		5.		3.6		7.7		3.12		5.0	BOD					
		40.		40.		39.0		40.		20.	COD					
		.48		.61		.41		43		.05	NIT					

JAMES F. MacLAREN LTD.

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SWMM WORKSHOP
BRUCEWOOD LUMPING DEMO.

SUBMITTED BY M A
JOB NUMBER 10680
PAGE NO. 2

	1 2 3 4 5	6 7 8 9 10	11 12 13 14 15	16 17 18 19 20	21 22 23 24 25	26 27 28 29 30	31 32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48 49 50	51 52 53 54 55
9c		.05		.05		.07		.03		.03	PO4
		1.		1.		1.		1.		1.	GREASE
											PB
											CL
11		1	1		36		70.15				.0057
		2	1		39		98.90				.0057
12	2	1									
13	1.0	20									

TRANSPORT CARDS

211

	1 2 3 4 5	6 7 8 9 10	11 12 13 14 15	16 17 18 19 20	21 22 23 24 25	26 27 28 29 30	31 32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48 49 50	51 52 53 54 55
11	BRUCEWOOD LUMPING DEMONSTRATION										
12	5	80	2	2	2	1	0	3	4		
13		300.				2					
14	0	0	0	1	0	0					
15	1	0		1.6							
	2	101		1.6							
	3	102		1.6							
	101	1		1	921.7		3.25		.425		.013
	102	2		1	725.7		3.25		1.045		.013
27	3										
29	1	2									
30	2	3									

```
        SWMM WORKSHOP - BRUCEWOOD LUMPING DEMONSTRATION

        STORM OF AUG 29, 1975  -2 SUBCATCHMENTS, 59 IN. PIPE ONLY


BASIN NUMBER    2

NUMBER OF TIME STEPS    80

INTEGRATION TIME INTERVAL (MINUTES),     5.00

25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

FOR  70 RAINFALL STEPS, THE TIME INTERVAL IS    5.00 MINUTES


FOR RAINGAGE NUMBER  1,  RAINFALL HISTORY IS

     0.24      0.0       0.0       0.0       0.0       0.0       0.0       0.12      0.0       0.12
     0.12      0.24      0.0       0.12      0.12      0.12      0.0       0.12      0.0       0.12
     0.0       0.12      0.0       0.0       0.12      0.0       0.0       0.12      0.0       0.12
     0.12      0.0       0.0       0.12      0.0       0.0       0.0       0.0       0.0       0.0
     0.0       0.0       0.0       0.12      0.0       0.0       0.24      0.12      0.0       0.0
     0.12      0.12      0.24      0.12      0.12      0.12      0.12      0.36      0.24      0.12
     0.12      0.12      0.0       0.12      0.12      0.12      0.12      0.0       0.12      0.0
```

REMAINDER OF OUTPUT NOT
INCLUDED IS SIMILAR TO
BRUCEWOOD OUTPUT IN RUNOFF
WORKSHOP HANDOUT

```
* * * * *  G U T T E R   A N D   P I P E   D A T A  * * * * *

GUTTER       GUTTER          WIDTH      LENGTH       SLOPE      SIDE SLOPES        MANNING        OVERFLOW
NUMBER     CONNECTION        (FT)        (FT)       (FT/FT)      L        R           N              (IN)

 1  *  10       1              3.3        620.       0.003       0.0     0.0        0.013          10.00
 2  *  20       2              3.3       1000.       0.011       0.0     0.0        0.013          10.00

TOTAL NUMBER OF GUTTERS/PIPES.   2

ASTERISK (*) DENOTES CIRCULAR PIPE, DIAMETER=.WIDTH.
```

```
* * * * *  S U B C A T C H M E N T   D A T A  * * * * *

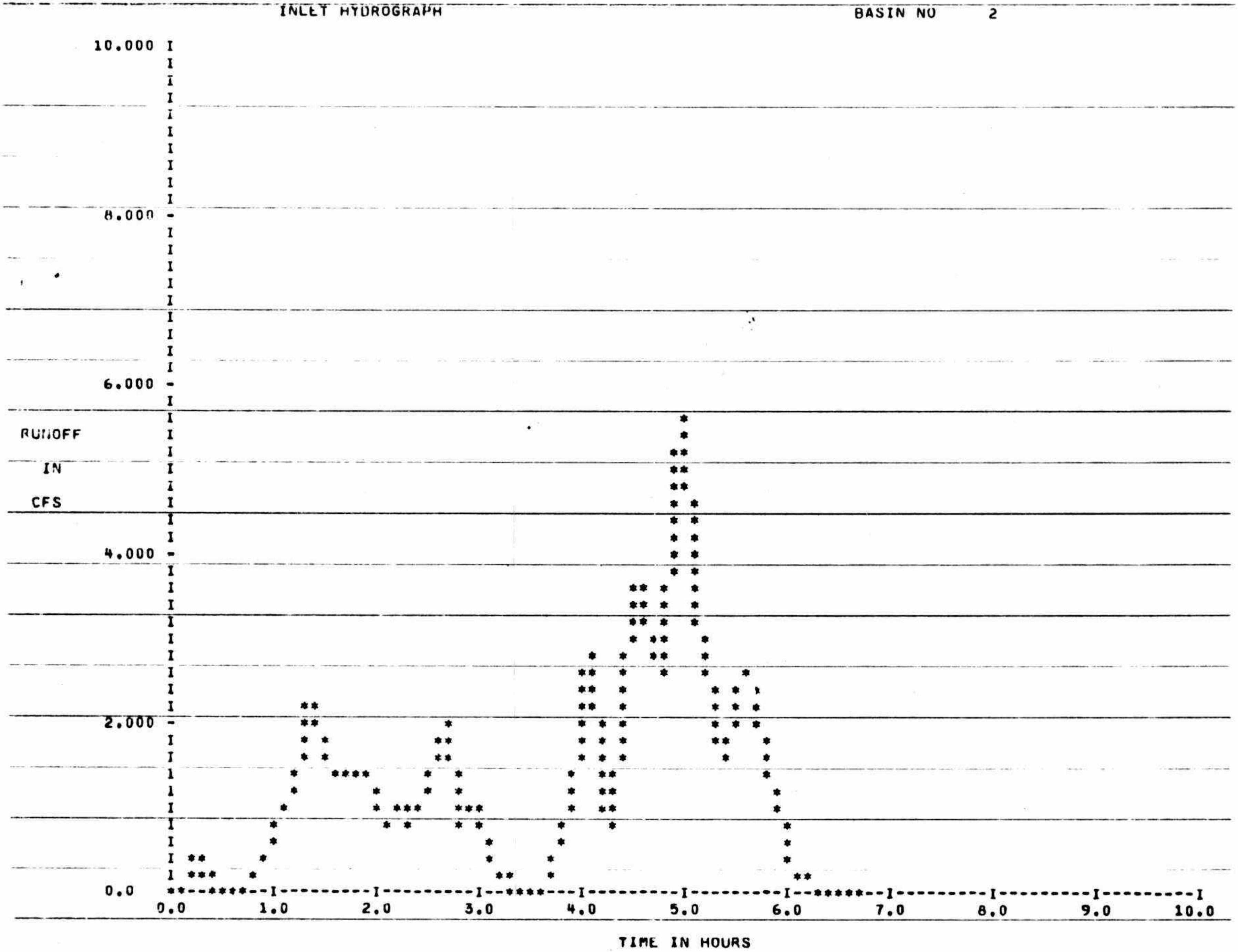
SUBCATCH-  GUTTER   WIDTH    AREA   PERCENT    SLOPE    RESISTANCE FACTOR  SURFACE STORAGE(IN)     INFILTRATION  DECAY RATE  GAGE
MENT NO.  OR INLET  (FT)     (AC)   IMPERV.   (FT/FT)    IMPERV.    PERV.     IMPERV.    PERV.     RATE(IN/HR)     (1/SEC)     NO.
                                                                                                MAXIMUM MINIMUM
  1    1     10    8960.0    20.6   36.2      0.090      0.013     0.250      0.062     0.184    3.00     0.52     0.00115      1
  2    2     20   10953.0    27.7   52.1      0.025      0.013     0.250      0.062     0.184    3.00     0.52     0.00115      1

TOTAL NUMBER OF SUBCATCHMENTS,   2

TOTAL TRIBUTARY AREA (ACRES),   48.23
```

```
HYDROGRAPHS WILL BE LISTED FOR THE FOLLOWING   2 GUTTERS OR INLETS
          10   20


TOTAL RAINFALL (CU FT)                          0.752811E 05
TOTAL INFILTRATION (CU FT)                      0.411651E 05
TOTAL GUTTER FLOW AT INLET (CU FT)              0.303966E 05
TOTAL SURFACE STORAGE AT END OF STORM (CU FT)0.370014E 04
TOTAL SNOWMELT (CU FT)                          0.0
ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL,      0.02549
```


INLET HYDROGRAPH
BASIN NO 2
10.000
8.000
6.000
4.000
2.000
0.0
RUNOFF IN CFS
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
TIME IN HOURS

```
SWMM WORKSHOP - BRUCEWOOD LUMPING DEMONSTRATION

TOTAL SIMULATION TIME = 24000.0 SECONDS. TIME STEP = 300.0 SECONDS.

INFLOW POLLUTOGRAPHS AND HYDROGRAPHS AT THE FOLLOWING EXTERNAL ELEMENT NUMBERS:

    1      2

                                        SELECTED INLET HYDROGRAPHS - CFS
EXTERNAL
ELEMENT     TIME STEP
NUMBER         1          2          3          4          5          6          7          8          9          10

    1        0.030      0.113      0.143      0.086      0.041      0.023      0.014      0.017      0.041      0.075
             0.121      0.211      0.361      0.485      0.602      0.796      0.776      0.554      0.459      0.454
             0.451      0.451      0.451      0.370      0.267      0.315      0.331      0.258      0.312      0.410
             0.558      0.673      0.469      0.263      0.324      0.335      0.190      0.079      0.041      0.024
             0.016      0.011      0.008      0.053      0.208      0.288      0.353      0.783      0.987      0.556
             0.252      0.436      0.895      1.268      1.215      0.970      0.895      1.195      1.845      1.921
             1.305      0.942      0.784      0.560      0.575      0.798      0.896      0.777      0.560      0.457
             0.374      0.199      0.082      0.042      0.025      0.016      0.011      0.008      0.006      0.004

    2        0.045      0.200      0.278      0.171      0.071      0.037      0.022      0.031      0.087      0.155
             0.239      0.404      0.638      0.814      1.042      1.447      1.509      1.146      0.920      0.884
             0.874      0.872      0.872      0.735      0.543      0.601      0.636      0.517      0.594      0.769
             1.026      1.257      0.973      0.581      0.615      0.641      0.408      0.199      0.113      0.071
             0.048      0.034      0.025      0.085      0.325      0.498      0.635      1.365      1.852      1.210
             0.590      0.794      1.581      2.352      2.384      1.946      1.746      2.217      3.404      3.738
             2.692      1.893      1.556      1.152      1.103      1.470      1.707      1.543      1.151      0.920
             0.746      0.434      0.205      0.116      0.073      0.049      0.035      0.026      0.020      0.015
```

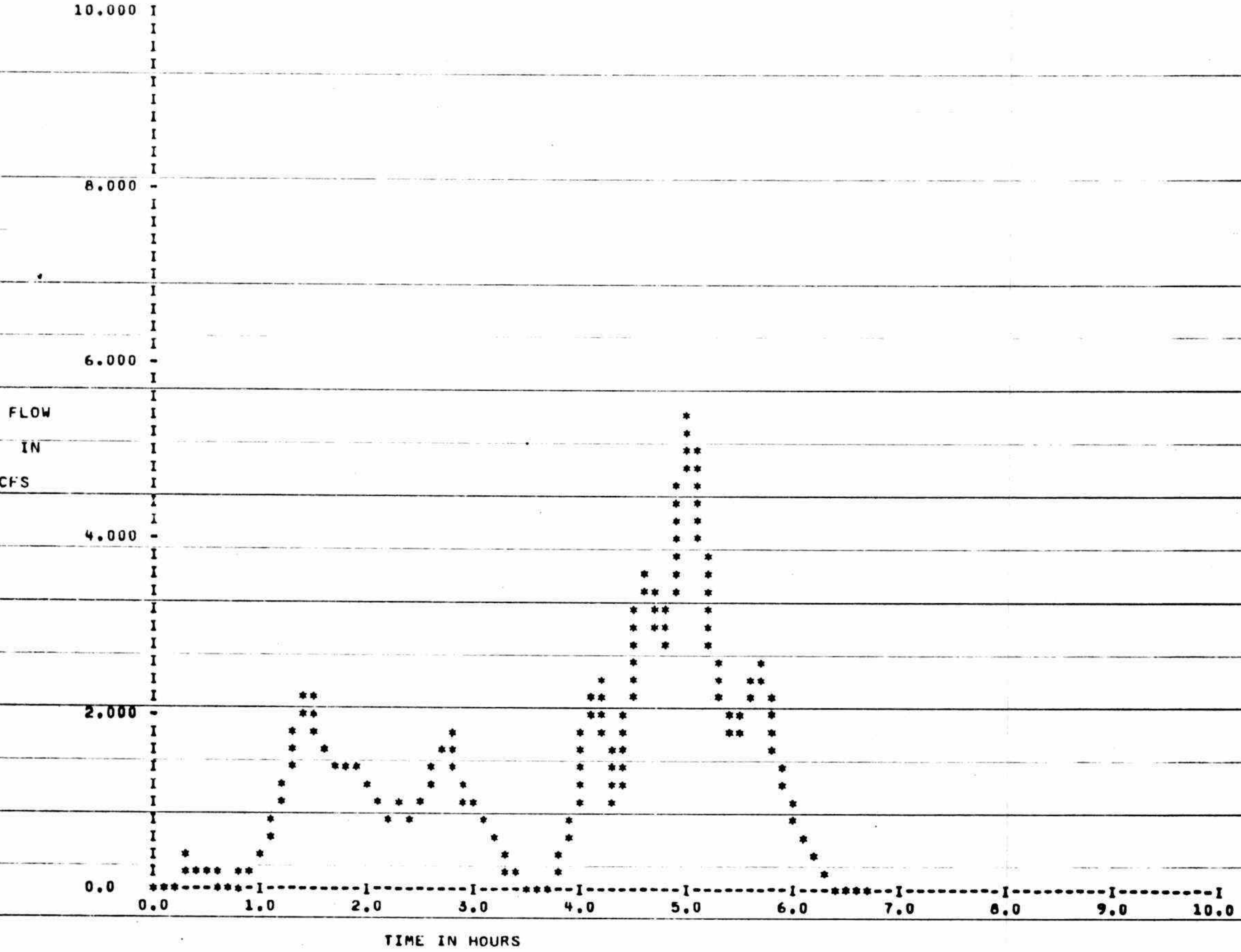
5.65

```
                               SELECTED OUTFLOW HYDROGRAPHS - CFS
EXTERNAL
ELEMENT    TIME STEP
NUMBER        1          2          3          4          5          6          7          8          9          10

   2        0.045      0.206      0.349      0.298      0.179      0.105      0.062      0.054      0.102      0.182
            0.289      0.487      0.797      1.113      1.512      2.049      2.276      1.905      1.492      1.356
            1.331      1.324      1.323      1.180      0.920      0.881      0.947      0.849      0.863      1.078
            1.435      1.805      1.615      1.064      0.902      0.962      0.760      0.446      0.258      0.152
            0.094      0.061      0.042      0.088      0.336      0.625      0.870      1.719      2.614      2.137
            1.161      1.090      2.047      3.273      3.634      3.117      2.704      3.166      4.745      5.617
            4.469      3.113      2.472      1.919      1.688      2.063      2.501      2.416      1.912      1.497
            1.213      0.832      0.464      0.266      0.155      0.095      0.062      0.043      0.031      0.023

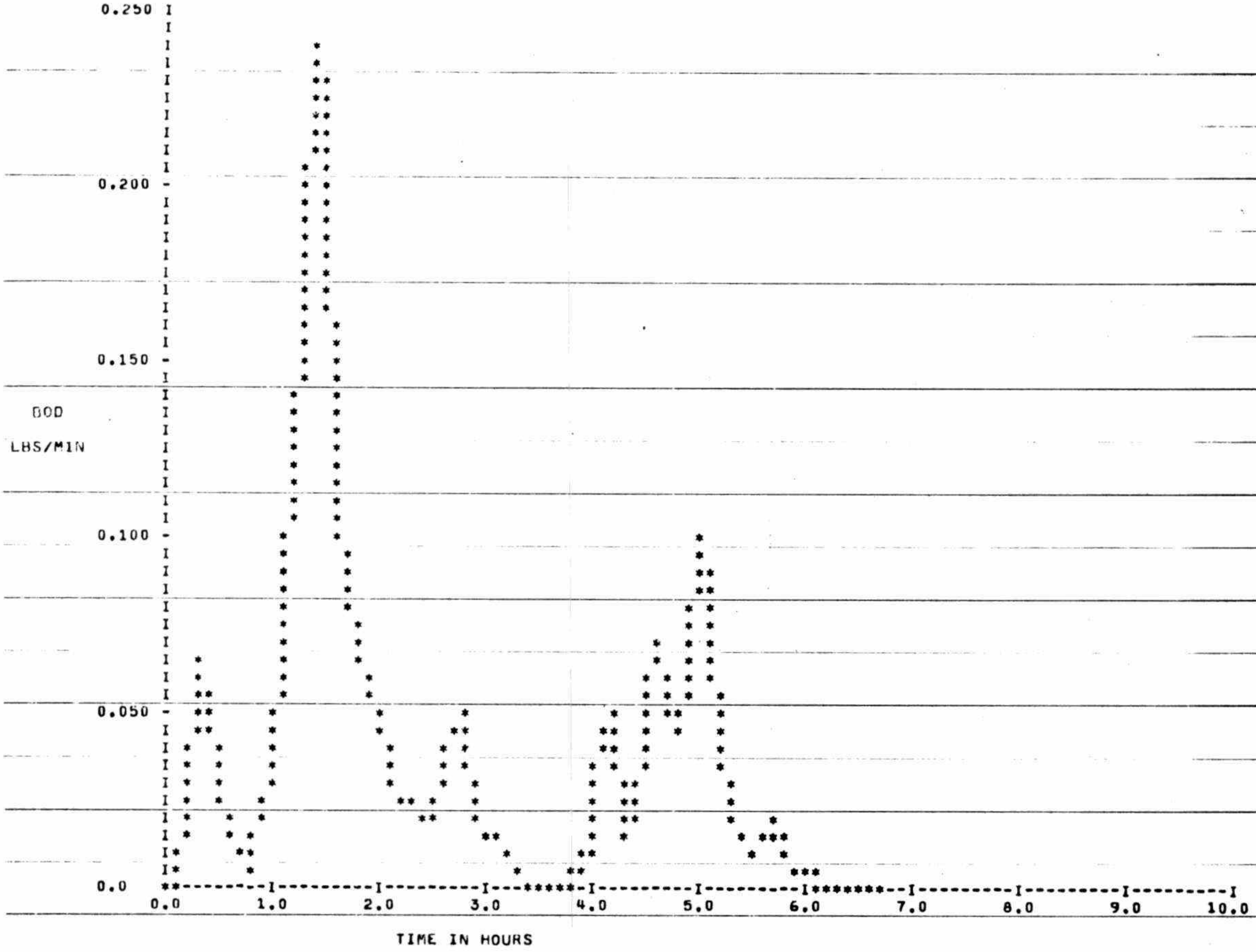
   3        0.006      0.066      0.220      0.337      0.282      0.173      0.102      0.062      0.061      0.111
            0.194      0.319      0.602      0.949      1.319      1.818      2.225      2.111      1.654      1.383
            1.337      1.326      1.323      1.258      1.066      0.879      0.906      0.919      0.841      0.946
            1.253      1.659      1.757      1.327      0.946      0.916      0.896      0.619      0.394      0.249
            0.148      0.092      0.060      0.049      0.122      0.396      0.746      1.243      2.289      2.473
            1.577      1.029      1.536      2.824      3.621      3.355      2.821      2.903      4.135      5.477
            5.008      3.514      2.641      2.138      1.749      1.845      2.348      2.507      2.134      1.656
            1.320      1.043      0.658      0.401      0.256      0.152      0.093      0.061      0.042      0.030
```

GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 3



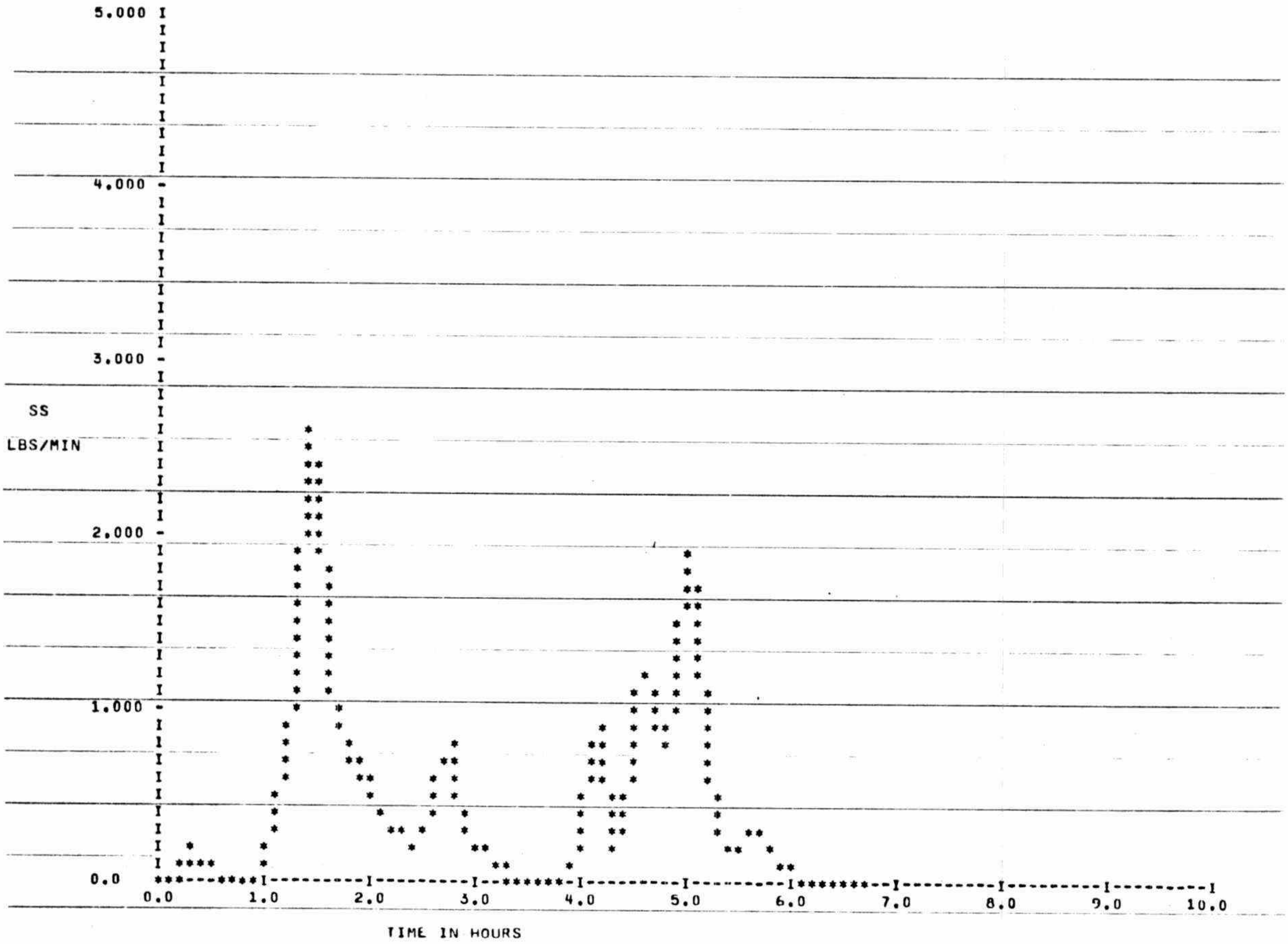
2 SUBCATCHMENTS

GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD

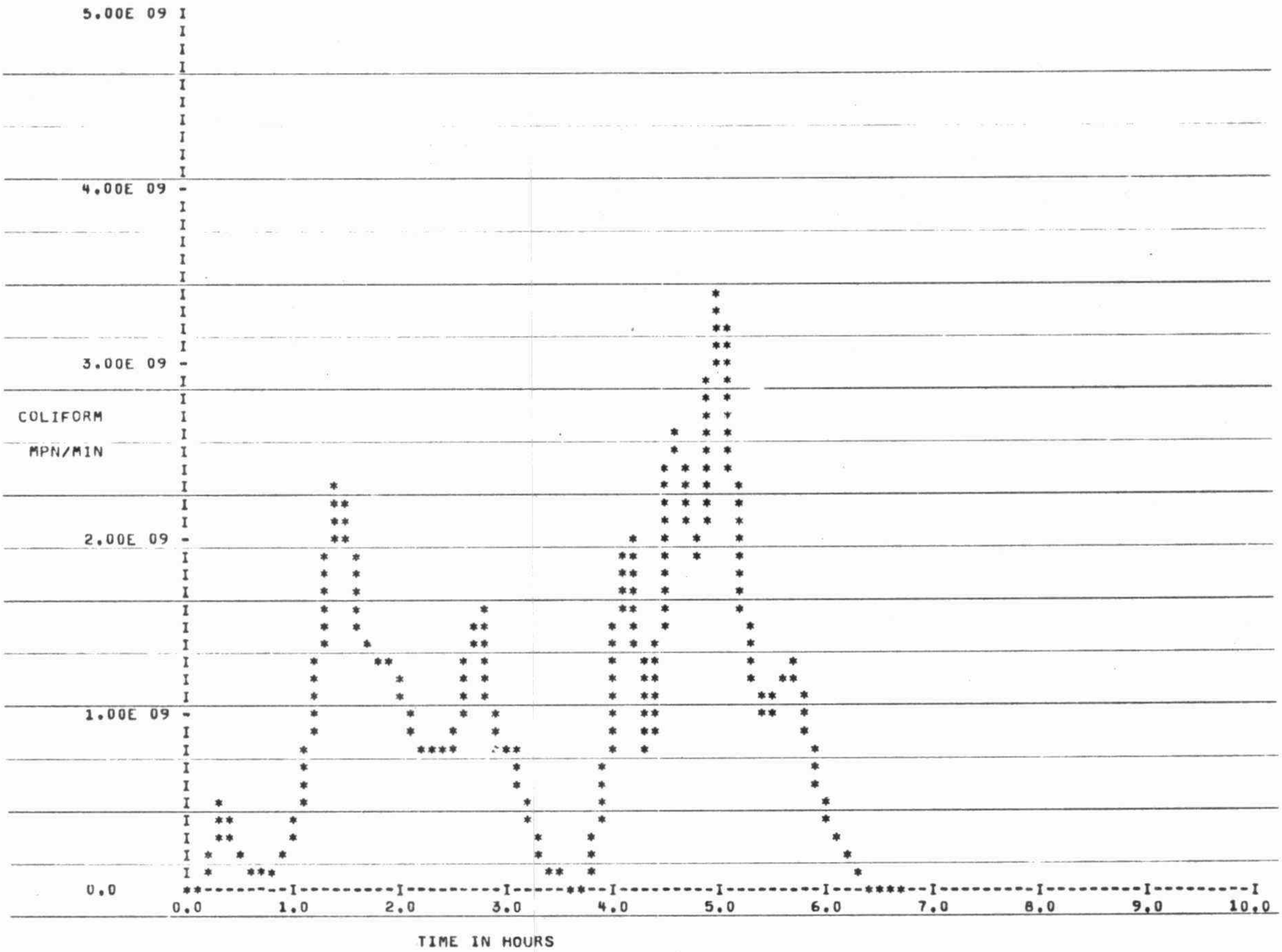


2 SUBCATCHMENTS

GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 3



GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD



```
        SWMM WORKSHOP -BRUCEWOOD LUMPING DEMONSTRATION

        STORM OF AUG 29,1975  - 1 SUBCATHMENT


BASIN NUMBER   3

NUMBER OF TIME STEPS   80

INTEGRATION TIME INTERVAL (MINUTES),     5.00

25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

FOR  70 RAINFALL STEPS, THE TIME INTERVAL IS   5.00 MINUTES

FOR RAINGAGE NUMBER  1,  RAINFALL HISTORY IS

     0.24      0.0       0.0       0.0       0.0       0.0       0.0       0.12      0.0       0.12
     0.12      0.24      0.0       0.12      0.12      0.12      0.0       0.12      0.0       0.12
     0.0       0.12      0.0       0.0       0.12      0.0       0.0       0.12      0.0       0.12
     0.12      0.0       0.0       0.12      0.0       0.0       0.0       0.0       0.0       0.0
     0.0       0.0       0.0       0.12      0.0       0.0       0.24      0.12      0.0       0.0
     0.12      0.12      0.24      0.12      0.12      0.12      0.12      0.36      0.24      0.12
     0.12      0.12      0.0       0.12      0.12      0.12      0.12      0.0       0.12      0.0
```

REMAINDER OF OUTPUT NOT
INCLUDED IS SIMILAR TO
BRUCEWOOD OUTPUT IN RUNOFF
WORKSHOP HANDOUTS

```
* * * *  S U B C A T C H M E N T   D A T A  * * * * *

UBCATCH-  GUTTER    WIDTH    AREA    PERCENT      SLOPE      RESISTANCE FACTOR   SURFACE STORAGE(IN)      INFILTRATION   DECAY RATE  GAGE
NT NO.  OR INLET   (FT)     (AC)    IMPERV.     (FT/FT)      IMPERV.     PERV.    IMPERV.      PERV.      RATE(IN/HR)     (1/SEC)     NO.
                                                                                                      MAXIMUM MINIMUM
 1    1        2   4000.0     48.2   48.4        0.052        0.013      0.250     0.062       0.184     3.00     0.52    0.00115      1

OTAL NUMBER OF SUBCATCHMENTS.     1

OTAL TRIBUTARY AREA (ACRES).     48.23
```

```
WATERSHED QUALITY DEFINITIONS

SUBAREA   LAND USE   TOTAL  GUTTER      NUMBER  OF
 NUMBER    CLASS.   LENGTH*10**2 FT.   CATCHBASINS

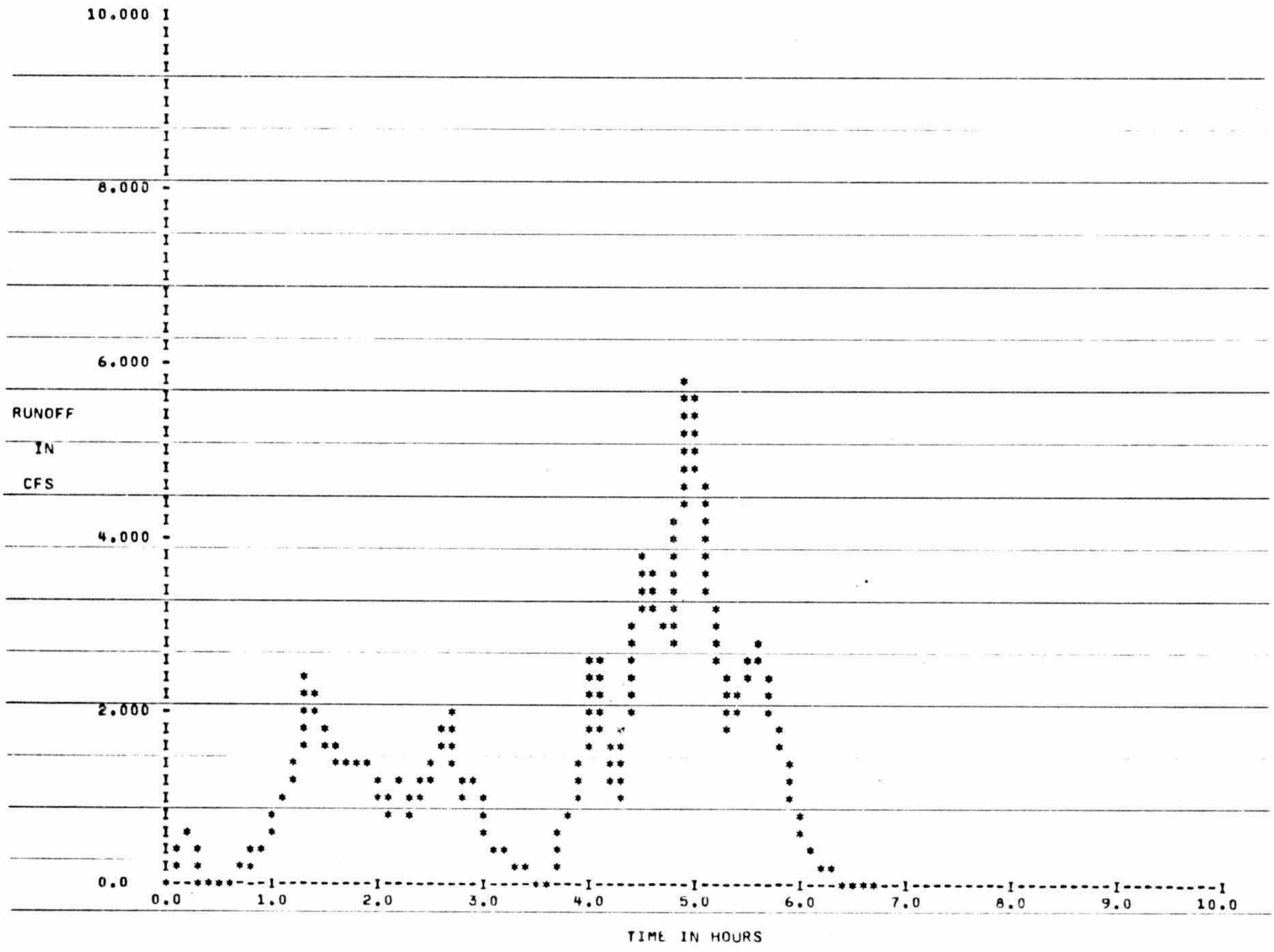
 1    1      1           169.05            75.00
```

```
DROGRAPHS WILL BE LISTED FOR THE FOLLOWING   1 GUTTERS OR INLETS

          2

TAL RAINFALL (CU FT)                          0.752812E 05
TAL INFILTRATION (CU FT)                      0.388530E 05
TAL GUTTER FLOW AT INLET (CU FT)              0.323761E 05
TAL SURFACE STORAGE AT END OF STORM (CU FT)0.404650E 04
TAL SNOWMELT (CU FT)                          0.0
RROR IN CONTINUITY, PERCENTAGE OF RAINFALL,     0.00738
```

INLET HYDROGRAPH BASIN NO 3



```
SWMM WORKSHOP -BRUCEWOOD LUMPING DEMONSTRATION

TOTAL SIMULATION TIME = 24000.0 SECONDS. TIME STEP = 300.0 SECONDS.

INFLOW POLLUTOGRAPHS AND HYDROGRAPHS AT THE FOLLOWING EXTERNAL ELEMENT NUMBERS:

   2

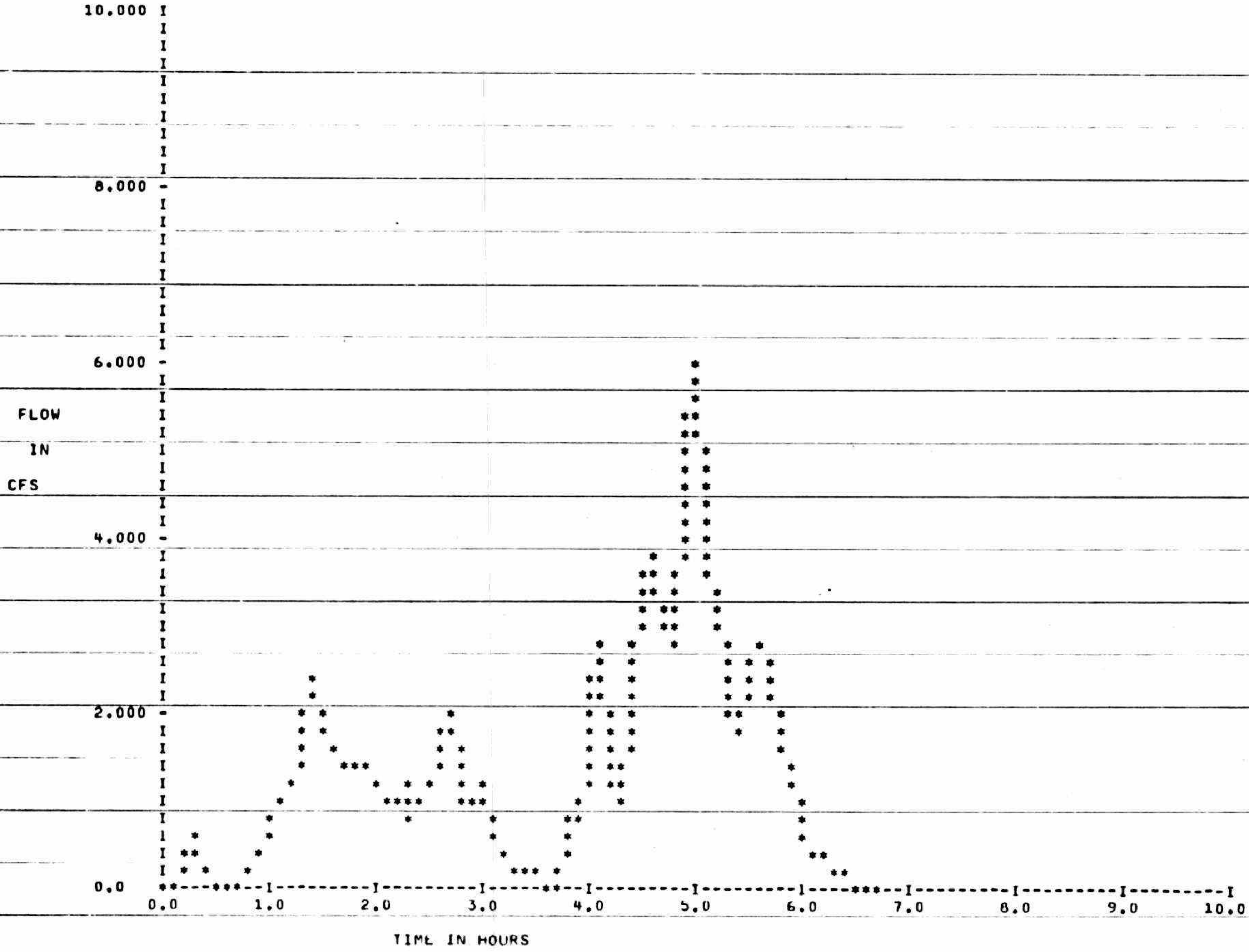
                                  SELECTED INLET HYDROGRAPHS - CFS
EXTERNAL
ELEMENT    TIME STEP
NUMBER       1          2          3          4          5          6          7          8          9          10

   2       0.212      0.549      0.404      0.097      0.046      0.026      0.017      0.105      0.254      0.328
           0.500      0.851      1.092      1.112      1.583      2.302      2.150      1.672      1.525      1.465
           1.437      1.424      1.418      1.042      0.862      1.153      0.928      0.810      1.121      1.276
           1.786      1.967      1.224      0.939      1.198      0.950      0.493      0.305      0.206      0.147
           0.110      0.084      0.067      0.289      0.725      0.701      1.098      2.556      2.675      1.413
           1.016      1.677      2.889      3.813      3.573      3.022      2.895      3.920      5.816      5.632
           3.950      3.139      2.461      1.785      2.023      2.544      2.722      2.315      1.733      1.552
           1.101      0.555      0.337      0.224      0.158      0.117      0.090      0.070      0.057      0.046
```

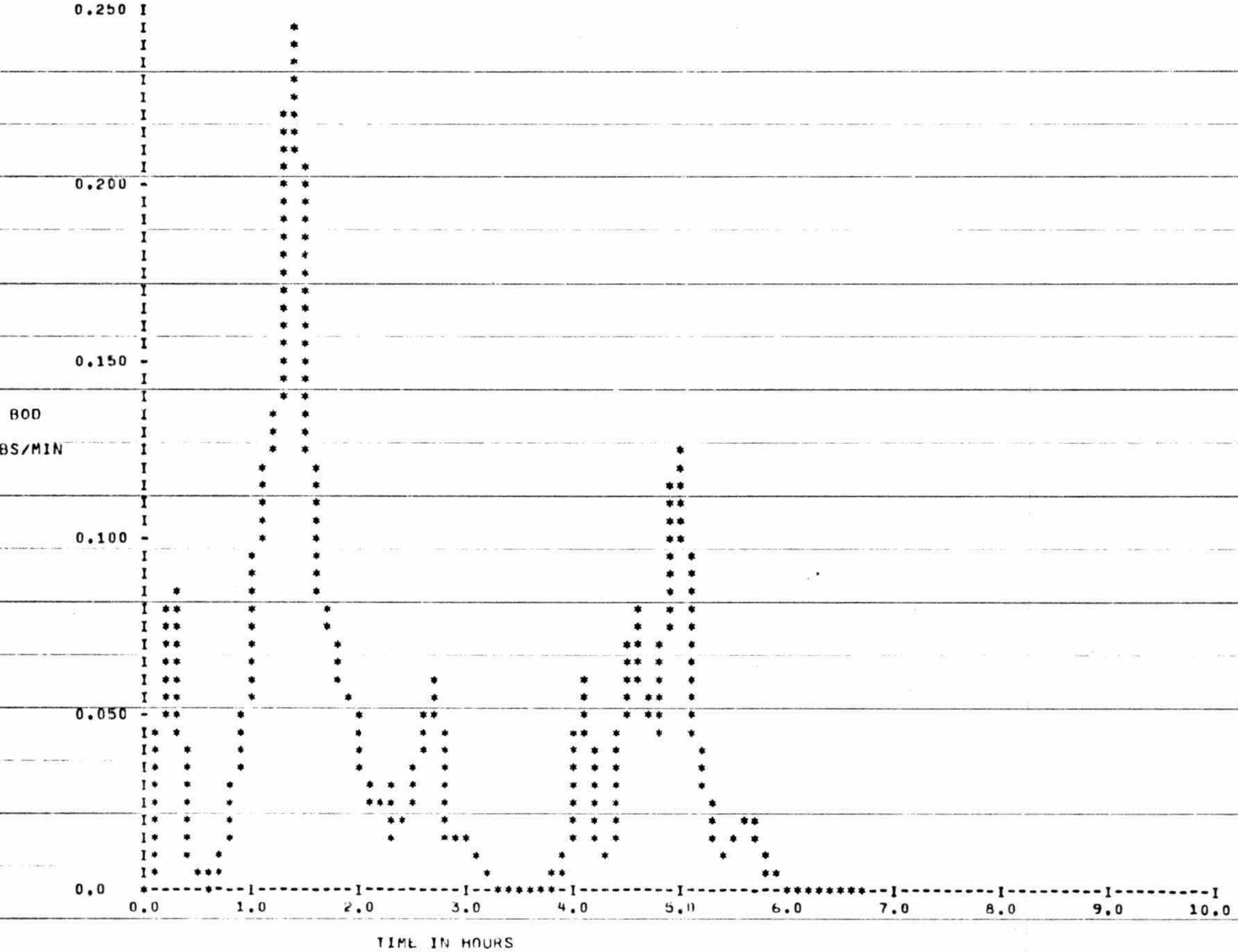
```
                                        SELECTED OUTFLOW HYDROGRAPHS - CFS
EXTERNAL
ELEMENT    TIME STEP
NUMBER        1         2         3         4         5         6         7         8         9        10

   3        0.029     0.268     0.511     0.353     0.101     0.045     0.026     0.029     0.122     0.258
            0.357     0.635     0.979     1.119     1.319     1.998     2.319     1.870     1.547     1.491
            1.444     1.429     1.420     1.253     0.933     0.956     1.107     0.851     0.917     1.228
            1.529     1.942     1.628     1.010     1.021     1.140     0.747     0.412     0.296     0.202
            0.144     0.108     0.083     0.098     0.387     0.762     0.837     1.832     2.840     1.998
            1.094     1.283     2.390     3.551     3.774     3.201     2.896     3.442     5.185     5.953
            4.542     3.286     2.739     2.036     1.824     2.343     2.701     2.518     1.968     1.582
            1.340     0.845     0.443     0.326     0.219     0.155     0.115     0.088     0.069     0.056
```

GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 3

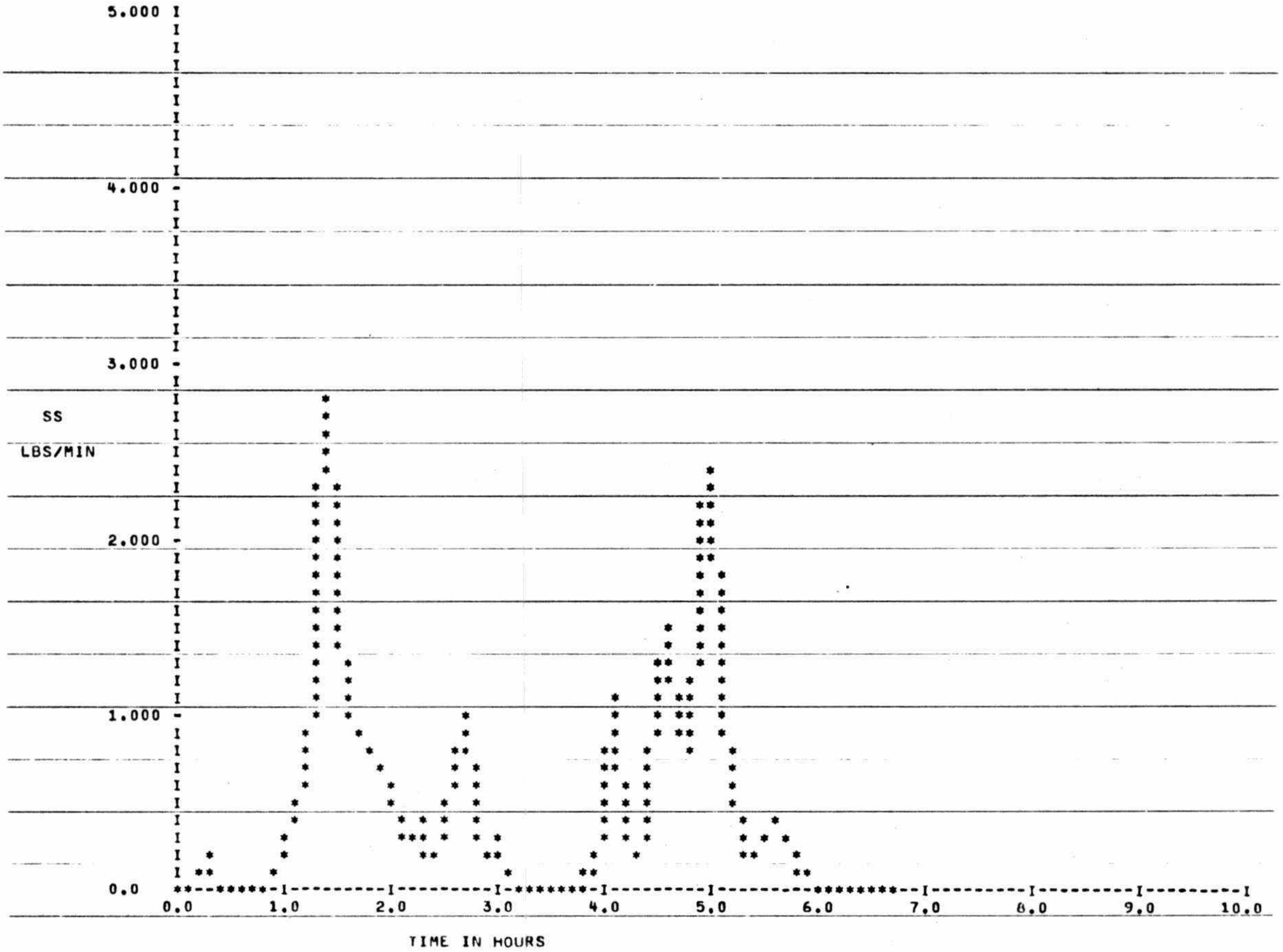


GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 3

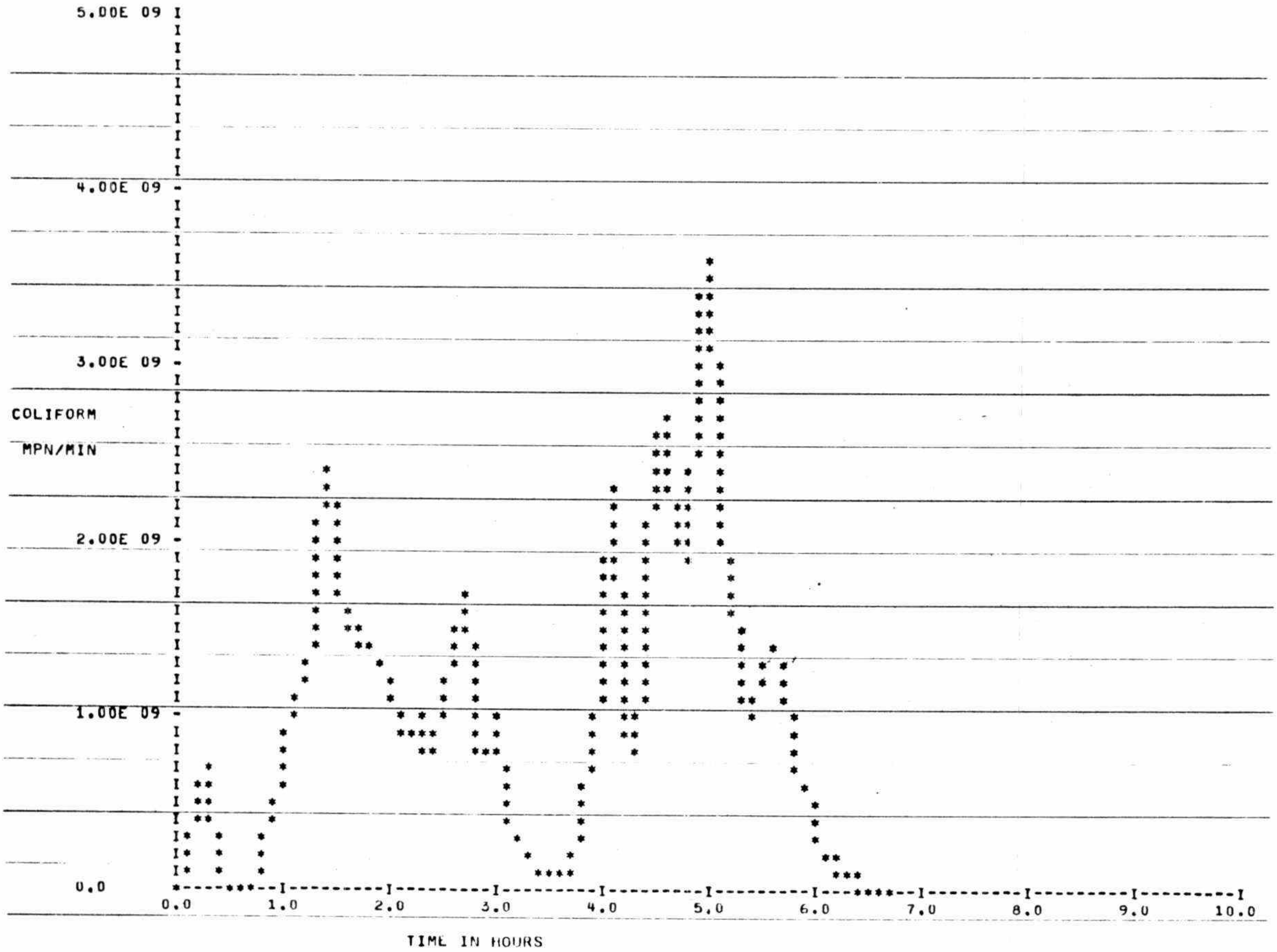


1 SUBCATCHMENT

GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 3



GRAPH OF TRANSPORT OUTPUT DATA SET - BRUCEWOOD 3



JAMES F. MacLAREN LTD.

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS	SWMM WORKSHOP LUMPING PROBLEM	SUBMITTED BY M.A	
		JOB NUMBER 10680	PAGE NO. 1/2

```
CARD GROUP |
1          |SWMM WORKSHOP - RUNOFF BLOCK
           |LUMPING EXAMPLE NO.1 - 2YR DESIGN STORM
2          |    1   40  0 0   5.    1  25.    1 1.08    1
3          |   20   5.
4          |  .12  .14  .16  .18  .22  .29  .42  .91 2.86 1.16
           |  .67  .48  .37  .31  .27  .24   21  .19   18    0
4A         |         0        30       1.0       0.5
4B         |   40   40   40   40   40   40   40   40   40   40   40   40   40   40   40   40
           |   40   40   40   40   40   40   40   40   40   40   40   40   40   40   40   40
           |   40   40   40   40   40   40   40   40
5          |       100   10    2    1.50    619.    .005                    .013
6 →Blank   |
7          |    1    1  1003031. 6.6145.50  .03 .013  .25 .062 .184  3.0  .52    .00115
8          |
8A         |    1  25.  .25  65.  .60  2.0  2.0  2.0 .013  .25
9          |         1        15         7         1       20.      100.    0    2
9A         |       0.7       2.3       3.3       4.6       1.5
9B         |       1.0
           |      100.      100.      100.      100.      100.  SGT-S
           |     1000.     1000.     1000.     1000.     1000.  SUS-S
           |   .13E  7   .27E  7   .17E  7    .1E  7         0  COLIF
9C         |        5.       3.6       7.7      3.12       5.0  BOD
           |       40.       40.       40.       40.       20.  COD
           |       .48       .61       .41       .43       .05  NIT
           |       .05       .05       .07       .03       .03  PO4
           |        1.        1.        1.        1.        1.  GREASE
           |                                                    LEAD
           |                                                    CL
```

JAMES F. MacLAREN LTD.

GENERAL PURPOSE DATA FORM

SPECIAL KEYPUNCH INSTRUCTIONS

SWMM WORKSHOP

LUMPING PROBLEM

SUBMITTED BY MA

JOB NUMBER

PAGE NO. 2/2

	1 2 3 4 5	6 7 8 9 10	11 12 13 14 15	16 17 18 19 20	21 22 23 24 25	26 27 28 29 30	31 32 33 34 35	36 37 38 39 40	41 42 43 44 45	46 47 48 49 50	51 52 53 54 55
10	1	.78	110.	.2	1.	1.20					
11		.1	1		12		13.25		182.		.0057
12	1	1									
13	1.0										

```
          SWMM WORKSHOP - RUNOFF BLOCK

          LUMPING EXAMPLE NO.1 - 2YR DESIGN STORM



 BASIN NUMBER    1

 NUMBER OF TIME STEPS    40

 INTEGRATION TIME INTERVAL (MINUTES),     5.00

 25.0 PERCENT OF IMPERVIOUS AREA HAS ZERO DETENTION DEPTH

 EROSION FOR SUBCATCHMENTS IS TO BE MODELED.
 HIGHEST 30 MIN. RAIN INTENSITY IS  1.08 IN/HR

 FOR  20 RAINFALL STEPS, THE TIME INTERVAL IS    5.00 MINUTES


 FOR RAINGAGE NUMBER  1,  RAINFALL HISTORY IS

      0.12      0.14      0.16      0.18      0.22      0.29      0.42      0.91      2.86      1.16
      0.67      0.48      0.37      0.31      0.27      0.24      0.21      0.19      0.18      0.0

  DEGREE HOUR MELT RATE =   0.0

  TEMPERATURE OF SNOW BASE =      30.0

  WIND FACTOR =          0.00500

  GAMMA FACTOR =          0.07913

  TEMPERATURE AT EACH TIME STEP
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
       40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0      40.0
```

```
* * * * *  G U T T E R   A N D   P I P E   D A T A  * * * * *

GUTTER      GUTTER        WIDTH      LENGTH      SLOPE      SIDE SLOPES      MANNING      OVERFLOW
NUMBER    CONNECTION      (FT)        (FT)      (FT/FT)      L      R           N           (IN)

  1  * 100      10          1.5        619.      0.005       0.0    0.0       0.018        10.00

TOTAL NUMBER OF GUTTERS/PIPES,     1

ASTERISK (*) DENOTES CIRCULAR PIPE, DIAMETER=.WIDTH.
```

```
* * * * *  S U B C A T C H M E N T   D A T A  * * * * *

SUBCATCH-  GUTTER   WIDTH   AREA  PERCENT    SLOPE   RESISTANCE FACTOR  SURFACE STORAGE(IN)    INFILTRATION  DECAY RATE  GAGE
MENT NO.  OR INLET  (FT)    (AC)  IMPERV.   (FT/FT)   IMPERV.    PERV.   IMPERV.      PERV.     RATE(IN/HR)    (1/SEC)     NO.
                                                                                             MAXIMUM MINIMUM
   1    1    100   3031.0    6.6   45.5     0.030     0.013     0.250    0.062       0.184     3.00    0.52   0.00115      1

TOTAL NUMBER OF SUBCATCHMENTS,    1

TOTAL TRIBUTARY AREA (ACRES),    6.61
```

```
          *** SNOW DATA ***

SUBCATCH-  PERCENT  W.E.       PERCENT   W.E.      PERCENT INITAL F.W.  PERCENT   RESISTANCE FACTOR
MENT NO.   IMPERV.  (IN)       PERVIOUS  (IN)       IMPERV.   PERV.     F.W.H.C.  IMPERV.    PERV.

    1        25.0    0.250       65.0     0.600       2.00      2.00      2.00     0.130E-01 0.250
```

```
ARRANGEMENT OF SUBCATCHMENTS AND GUTTERS/PIPES

     GUTTER      TRIBUTARY GUTTER/PIPE                                          TRIBUTARY SUBAREA
     OR PIPE

     100                                                                        1

     INLET       TRIBUTARY GUTTERS AND/OR PIPES                           TRIBUTARY SUBAREAS

      10         100
```

```
              QUALITY DEFAULT PARAMETER CHANGES

             NQS= 10

  DDFACT     0.70000       2.3000       3.3000       4.6000       1.5000

  SET-S       100.00       100.00       100.00       100.00       100.00
  SUS-S       1000.0       1000.0       1000.0       1000.0       1000.0
  COLIF      0.65000E 07  0.27000E 07  0.17000E 07  0.10000E 07  0.0
  BOD         5.0000       3.6000       7.7000       3.1200       5.0000
  COD         40.000       40.000       39.000       40.000       20.000
  NIT        0.48000      0.61000      0.41000      0.43000      0.50000E-01
  PO4        0.50000E-01  0.50000E-01  0.70000E-01  0.30000E-01  0.30000E-01
  GREASE      1.0000       1.0000       1.0000       1.0000       1.0000
  PB         0.0          0.0          0.0          0.0          0.0
  CL         0.0          0.0          0.0          0.0          0.0



      .....QUALITY SIMULATION INCLUDED IN THIS RUN.....


      INPUT PARAMETERS AS FOLLOWS


      NUMBER OF CONSTITUENTS        10

      NUMBER OF DRY DAYS          15.0

      STREET CLEANING FREQ         7.0 DAYS

      PASSES PER CLEANING            1

      STD CATCHBASIN VOLUME     20.00 FT3

      CATCHBASIN CONTENTS BOD   100.0 MG/L

      METHOD FOR CALCULATING SS:
        SAME AS FOR ALL OTHER
        POLLUTANTS (VOL. I).
        ISS = 0
```

```
WATERSHED QUALITY DEFINITIONS

SUBAREA   LAND USE   TOTAL  GUTTER        NUMBER  OF
 NUMBER    CLASS.   LENGTH*10**2 FT.   CATCHBASINS

 1    1      1           13.25            12.00
```

```
HYDROGRAPHS WILL BE LISTED FOR THE FOLLOWING   1 GUTTERS OR INLETS

          10

GUTTER    1 SURCHARGED, SURCHARGE =        418. CU FT, FLOW =        5.8 CFS, TIME      3000.0 SEC



TOTAL RAINFALL (CU FT)                               0.187554E 05

TOTAL INFILTRATION (CU FT)                           0.120346E 05

TOTAL GUTTER FLOW AT INLET (CU FT)                   0.981180E 04

TOTAL SURFACE STORAGE AT END OF STORM (CU FT)0.550009E 03

TOTAL SNOWMELT (CU FT)                               0.343509E 04

ERROR IN CONTINUITY, PERCENTAGE OF RAINFALL,   -0.92812
```

```
* * * * *   S U M M A R Y   O F   F I N A L   S N O W   C O N D I T I O N S   * * * * *

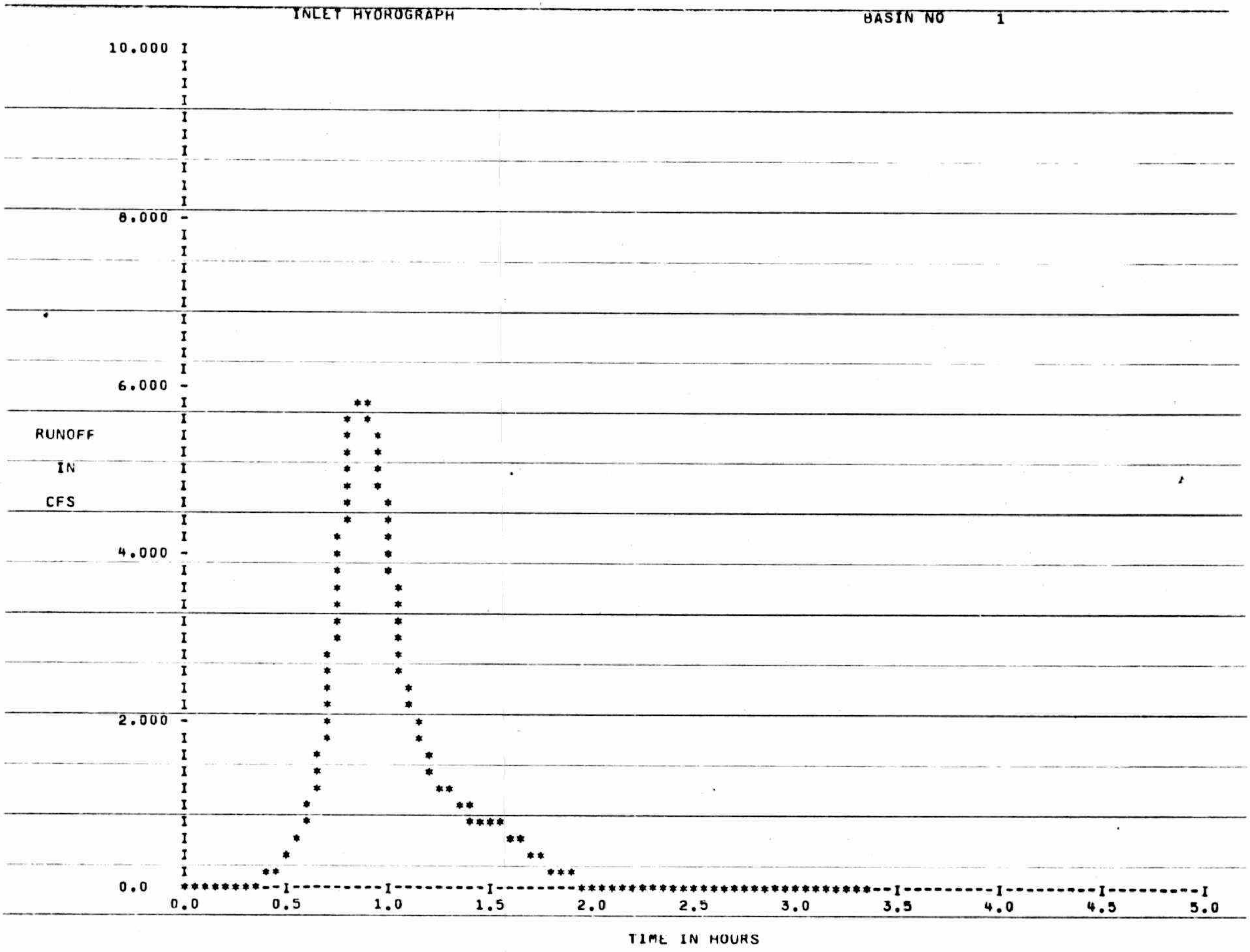
WATERSHED    SNOW COVERED AREA (SQFT)        DEPTH OF SNOW (FT)             FREE WATER (FT)
              IMPERV          PERV        IMPERV          PERV        IMPERV          PERV

    1         32752.        102000.       0.0            0.02367      0.00000        0.00047
```

```
                        RAINFALL HYETOGRAPH                                         BASIN NO    1
      5.000 I
            I
            I
            I
            I
            I
            I
            I
            I
            I
      4.000 -
            I
            I
            I
            I
            I
            I
            I
            I
            I
      3.000 -
            I            ***
            I            * *
RAINFALL    I            * *
            I            * *
   IN       I            * *
            I            * *
IN /  HR    I            * *
            I            * *
            I            * *
      2.000 -            * *
            I            * *
            I            * *
            I            * *
            I            * *
            I            * *
            I            * *
            I            * *
            I            * ***
            I            *   *
      1.000 -            *   *
            I           **   *
            I           *    *
            I           *    **
            I           *     *
            I           *     ***
            I         ***       ***
            I       ***           ****
            I  ******              ********
            ****                            *
        0.0 I---------I---------I---------I-************************************--I---------I---------I---------I
           0.0       0.5       1.0       1.5       2.0       2.5       3.0       3.5       4.0       4.5       5.0

                                                        TIME IN HOURS

                        RAINGAGE LEGEND     1 = *
```


INLET HYDROGRAPH
BASIN NO 1
10.000
8.000
6.000
4.000
2.000
0.0
RUNOFF
IN
CFS
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
TIME IN HOURS

```
THIS IS A SUMMARY OF THE QUANTITY AND QUALITY RESULTS

SWMM WORKSHOP - RUNOFF BLOCK
LUMPING EXAMPLE NO.1 - 2YR DESIGN STORM

NSTEP  NPTS  NGS  DELT       TZERO       TAREA

  40      1   11   300.        0.0         6.6

THE FOLLOWING INLET/GUTTER NUMBERS WILL BE PRINTED FOR SELECTED TIME STEPS
    10


*****  NOTE:  ONLY THE FIRST THREE POLLUTANTS ARE TRANSFERED TO OTHER BLOCKS.
```

```
     SWMM WORKSHOP - RUNOFF BLOCK
     LUMPING EXAMPLE NO.1 - 2YR DESIGN STORM

     SUMMARY OF QUANTITY AND QUALITY RESULTS AT LOCATION  10

     FLOW IN CFS AND QUALITY IN MG/L (AND COLIF IN MPN/L)

   TIME      FLOW        BOD         SUS-S          F         COD       SET-S      NIT       PO4         GREASE       PB           CL
                         SUS-SNE
 0   5.0   0.174E-0    0.0          0.0         0.0           0.0       0.0        0.0       0.0         0.0          0.0          0.0
                       0.0
 0  10.0   0.141E-0    43.4         579.        0.120E 07   137.        0.521      0.637     0.640E-01   0.184        0.245E-02   236.
                       12.1
 0  15.0   0.391E-0    53.1         681.        0.150E 07   168.        0.656      0.816     0.820E-01   0.231        0.307E-02   296.
                       15.5
 0  20.0   0.739E-0    54.3         639.        0.161E 07   172.        0.710      0.916     0.921E-01   0.247        0.328E-02   317.
                       17.6
 0  25.0   0.157       50.2         469.        0.164E 07   158.        0.772      1.13      0.114       0.253        0.336E-02   324.
                       22.3
 0  30.0   0.362       41.0         322.        0.163E 07   128.        0.933      1.59      0.160       0.251        0.333E-02   321.
                       32.5
 0  35.0   0.732       29.0         262.        0.158E 07    88.3       1.31       2.32      0.232       0.243        0.323E-02   311.
                       48.6
 0  40.0     1.40      17.5         303.        0.148E 07    47.2       2.48       3.72      0.372       0.228        0.303E-02   292.
                       79.6
 0  45.0     3.53      12.8         475.        0.124E 07    16.8      11.2        8.00      0.801       0.192        0.255E-02   245.
                       173.
 0  50.0     5.77      9.74         361.        0.928E 06     7.50     13.8        7.55      0.755       0.143        0.190E-02   183.
                       163.
 0  55.0     5.73      8.22         250.        0.821E 06     5.22     12.2        6.73      0.673       0.126        0.168E-02   162.
                       145.
 1   0.0     4.23      6.83         222.        0.753E 06     4.66      7.67       5.60      0.560       0.116        0.154E-02   146.
                       121.
 1   5.0     2.42      3.35         143.        0.505E 06     3.11      3.11       2.67      0.268       0.777E-01    0.103E-02    99.6
                       57.8
 1  10.0     1.74      2.26         124.        0.427E 06     2.63      1.79       1.75      0.175       0.657E-01    0.873E-03    84.1
                       37.8
 1  15.0     1.27      1.65         122.        0.385E 06     2.37      1.13       1.24      0.124       0.592E-01    0.787E-03    75.8
                       26.7
 1  20.0     1.02      1.35         124.        0.358E 06     2.20      0.841      0.984     0.985E-01   0.551E-01    0.732E-03    70.6
                       21.1
 1  25.0   0.856       1.15         124.        0.338E 06     2.08      0.680      0.823     0.824E-01   0.520E-01    0.691E-03    66.6
                       17.6
 1  30.0   0.754       1.03         122.        0.322E 06     1.98      0.595      0.726     0.727E-01   0.495E-01    0.658E-03    63.4
                       15.5
 1  35.0   0.682       0.951        121.        0.308E 06     1.90      0.542      0.661     0.662E-01   0.474E-01    0.631E-03    60.8
                       14.1
 1  40.0   0.569       0.872         93.6       0.298E 06     1.83      0.497      0.596     0.597E-01   0.459E-01    0.610E-03    58.8
                       12.7
 1  45.0   0.364       0.778         51.0       0.291E 06     1.79      0.448      0.516     0.517E-01   0.448E-01    0.596E-03    57.5
                       10.9
 1  50.0   0.188       0.694         35.9       0.288E 06     1.77      0.413      0.443     0.444E-01   0.443E-01    0.589E-03    56.7
                       9.28
 1  55.0   0.112       0.632         27.0       0.285E 06     1.75      0.390      0.390     0.391E-01   0.439E-01    0.583E-03    56.2
                       8.10
 2   0.0   0.858E-0    0.581         19.5       0.282E 06     1.74      0.371      0.345     0.346E-01   0.434E-01    0.578E-03    55.7
                       7.12
```

```
2  5.0    0.744E-0  0.544     14.3     0.280E 06   1.73     0.358     0.313     0.314E-01  0.431E-01  0.573E-03   55.3
                    6.42
2 10.0    0.691E-0  0.519     10.8     0.279E 06   1.71     0.349     0.292     0.293E-01  0.429E-01  0.570E-03   54.9
                    5.95
2 15.0    0.665E-0  0.503     8.62     0.277E 06   1.70     0.344     0.278     0.279E-01  0.426E-01  0.567E-03   54.6
                    5.65
2 20.0    0.651E-0  0.492     7.27     0.276E 06   1.70     0.340     0.270     0.271E-01  0.424E-01  0.564E-03   54.4
                    5.47
2 25.0    0.644E-0  0.486     6.44     0.275E 06   1.69     0.338     0.265     0.265E-01  0.422E-01  0.561E-03   54.1
                    5.35
2 30.0    0.640E-0  0.481     5.94     0.273E 06   1.68     0.337     0.261     0.262E-01  0.421E-01  0.559E-03   53.9
                    5.28
2 35.0    0.602E-0  0.477     5.63     0.272E 06   1.68     0.336     0.258     0.259E-01  0.419E-01  0.557E-03   53.7
                    5.22
2 40.0    0.480E-0  0.473     5.44     0.272E 06   1.67     0.335     0.255     0.256E-01  0.418E-01  0.556E-03   53.6
                    5.14
2 45.0    0.318E-0  0.469     5.33     0.271E 06   1.67     0.335     0.252     0.252E-01  0.418E-01  0.555E-03   53.5
                    5.07
2 50.0    0.196E-0  0.467     5.28     0.271E 06   1.67     0.334     0.250     0.251E-01  0.417E-01  0.554E-03   53.4
                    5.04
2 55.0    0.125E-0  0.466     5.25     0.270E 06   1.66     0.334     0.249     0.250E-01  0.416E-01  0.553E-03   53.3
                    5.02
3  0.0    0.841E-0  0.465     5.24     0.270E 06   1.66     0.334     0.249     0.250E-01  0.416E-01  0.553E-03   53.3
                    5.01
3  5.0    0.592E-0  0.465     5.23     0.270E 06   1.66     0.334     0.248     0.249E-01  0.416E-01  0.553E-03   53.3
                    5.00
3 10.0    0.432E-0  0.0      0.0       0.0         0.0      0.0       0.0       0.0        0.0        0.0         0.0
                    0.0
3 15.0    0.324E-0  0.0      0.0       0.0         0.0      0.0       0.0       0.0        0.0        0.0         0.0
                    0.0
3 20.0    0.250E-0  0.0      0.0       0.0         0.0      0.0       0.0       0.0        0.0        0.0         0.0
                    0.0
```

```
TOTAL SUSPENDED SOLIDS (INCLUDING S.S. FROM EROSION) TRANSFERRED TO THE SEWER FROM INLET AREAS DURING  40 TIME STEPS

INLET    EROSION       FLOW       SOIL    CROPPING  CONTROL    EROSION     TOTAL
  NO.  AREA(ACRES)  LENGTH(FT)  TYPE(K)   FACTOR    FACTOR    S.S.(MG)   S.S.(MG)

   1      0.78        110.00      0.20      1.00      1.20   0.4032E 08 0.6727E 08


        TOTAL EROSION CONTRIBUTION              TOTAL SUS-S

             0.40323E 08 MG                  0.67267E 08 MG
                    88.8 LB                         148.2 LB
```

STORM WORKSHOP

Proctor & Redfern Limited
Consulting Engineers

SHEET 1 OF 3

PROGRAM NAME STORM

EO NO

CARD TYPE

DATE

```
A1                                    STORM APPLICATION
A2      OVERFLOW ANALYSIS FOR WEST TORONTO STUDY AREA - 1973 PRECIPITATION DATA
A3                                 PARKSIDE DRIVE OVERFLOW
B1      1         0         0         0         0       1
B2     20         3
C1 OLD WESTON RD RAINGAUGE                      5                              1

C 730401   0  0  0  0  0  0  0  0  0  5  1  0  2  0  0  1  0  0  0  0  0  0  0  0
C 730402   0  1  0  0  1  0  1  1  0  2  4  1  1  4  1  2  5  2  1  1  1  1  0  0
      .
      .
      .
C
E1    WEST TORONTO        3       4.6       0.8
E2  2300.     0.3       0.8       0.9       0         0         0         0
E3   0.05     0.04      0.04      0.04      0.30      0.30      0.40      0.60      0.48      0.40
E3   0.20     0.04      0.04
F1SINGLE      60.0      54.0     275.0      7
F2     0.
F1MULTPL      20.0      54.0     430.0      3
F2
F1INDSTL      20.0      54.0     100.0      1
F2
```

Proctor & Redfern Limited

Consulting Engineers

SHEET 2 OF 2

PROGRAM NAME

ED NO

CARD TYPE

DATE

```
T1     1
T2  0.03       2       5       1       1       0       0
T3 0.016   0.022
T4     7      12      19      26      28
```

```
STORM, L2520, VERSION DATED MAY 1974
***********************************



                                 STORM APPLICATION
          OVERFLOW ANALYSIS FOR WEST TORONTO STUDY AREA - 1973 PRECIPITATION DATA
                             PARKSIDE DRIVE OVERFLOW


                   NWSHD     ISNO   NONURB     ISED    IQUAL    IEVNT
                       1        0        0        0        0        1


                        NSUMR     LEXT     LINE    LDATE      LHR
                           20        3        0       -6        0


                                 TITLE OF RAIN GAGE
                             OLD WESTON RD RAINGAUGE


                             IN    IFILE  ISTART     IEND        IR
                              5        0  730401   999999         1
```

RAINFALL DATA FOR OLD WESTON RD RAINGAUGE
HOURLY RAINFALL, IN HUNDRETHS OF AN INCH

YEAR	MO	DAY	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
1973	4	1	0	0	0	0	0	0	0	0	0	5	1	0	2	0	0	1	0	0	0	0	0	0	0	0	9
1973	4	2	0	1	0	0	1	0	1	1	0	2	4	1	1	4	1	2	5	2	1	1	1	1	0	0	30
1973	4	3	2	3	3	2	3	2	2	0	0	2	0	1	0	1	1	0	1	0	1	0	0	0	1	0	25
1973	4	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	5	4	3	1	2	2	1	25
1973	4	5	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1973	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	4
1973	4	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	3
1973	4	19	0	0	0	0	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
1973	4	22	0	0	0	0	0	0	0	0	0	1	6	0	3	0	0	0	0	0	0	0	0	0	0	0	10
1973	4	27	0	0	0	0	0	0	0	0	0	1	3	1	3	4	3	4	2	7	6	8	4	12	14	5	77
1973	4	28	2	0	1	2	0	0	0	0	0	0	0	2	0	1	0	0	1	0	0	0	0	0	0	0	9
1973	5	1	0	1	0	0	0	0	0	0	10	11	3	0	1	0	0	0	0	1	0	0	0	0	0	0	27
1973	5	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	16	0	0	0	18
1973	5	4	0	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	4
1973	5	8	0	0	1	1	0	0	1	0	0	0	1	13	12	3	1	3	0	6	7	1	0	11	2	0	63
1973	5	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
1973	5	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	17	6	11	0	99
1973	5	11	0	0	0	0	1	4	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
1973	5	12	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	5
1973	5	15	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
1973	5	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	6	3	0	0	0	12
1973	5	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
1973	5	21	2	1	4	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
1973	5	26	1	6	4	2	1	10	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	29
1973	5	28	3	4	3	0	12	12	1	37	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79
1973	5	31	3	3	1	1	9	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	23
1973	6	1	0	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8
1973	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
1973	6	5	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7	13
1973	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
1973	6	7	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
1973	6	9	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
1973	6	12	0	0	0	0	0	0	0	0	0	0	4	2	2	3	0	0	0	0	0	0	0	0	0	0	11
1973	6	16	0	0	0	0	0	0	2	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9
1973	6	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
1973	6	18	2	22	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36
1973	6	22	0	0	0	0	0	0	0	0	0	0	0	0	4	33	0	0	0	0	0	0	0	0	0	0	37
1973	6	24	0	0	0	0	7	7	6	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26
1973	6	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
1973	6	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	4	1	6
1973	6	28	2	2	0	0	1	0	0	0	0	0	0	0	0	1	0	58	10	1	0	0	0	0	0	0	75
1973	7	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1973	7	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	8	0	0	0	0	0	0	11
1973	7	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10
1973	7	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0	0	15
1973	7	14	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
1973	7	25	0	0	0	15	22	36	0	7	3	1	0	0	0	0	0	0	3	0	5	0	0	0	0	0	92
1973	7	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	13	0	0	43
1973	7	27	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	3	2	0	0	0	0	0	0	14
1973	7	28	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	3
1973	8	1	78	78	11	10	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180
1973	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
1973	8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	12	0	0	0	5	0	0	0	24
1973	8	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5
1973	8	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10

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                                         RAINFALL DATA FOR  OLD WESTON RD RAINGAUGE
                                                HOURLY RAINFALL, IN HUNDRETHS OF AN INCH

YEAR MO DAY      1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24 TOTAL

1973  8  20      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    9    1    0    0    0    0    10
1973  9  17      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    1    4    7    2    0    0   12    9    36
1973  9  18      0    7    0    1    1    4    0    0    1    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    14
1973  9  22      0    0    8   11    1    0   15   25    3    0    0    0    0   16    0    0    0    0    0    0    0    0    0    0    79
1973  9  23      0    0    0    0    0    0    0    0   14   17    6    0    0    3    0    0    0    0    0    0    0    0    0    0    40
1973 10   1      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1     1
1973 10   2      0    2    2    3   10    8    0    1    0    0    0    0    0    0    0    0    0    0    0    9   31    4    0    1    71
1973 10   4      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1    3    0    0    0    0    0    0    0     4
1973 10  13      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    5   13    4    1    2    0    0    2    0    27
1973 10  16      0    0    0    0    0    0    0    0    0    0    0    0    0    1    0    0    0    0    0    0    0    0    0    0     1
1973 10  17      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1     1
1973 10  18      0    0    0    2    2    0    0    3    0    0    0    0    0    0    1    0    0    0    0    0    0    0    0    0     8
1973 10  19      0    0    0    0    0    0    0    0    0    0    0    0    0    0    3    2    5    2    0    0    0    0    0    0    12
1973 10  27      0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    0    1     1
1973 10  28      0    1    1    1    0    1    1    1    0    0    0    0    0    1    4    1    4    9   12   17   14   11    4    1    84
1973 10  29      0    0    0   14    8    6    4    2    0    0    0    1    4    7    7    7    8   11   22   18    7    1    7    2   136
1973 10  30      0   15    2    0    0    3    4    0    2    2    4    6    7    3    4    4    1    1    5    2    2    0    0    0    67
1973 10  31      0    0    0    0    0    0    0    0    0    0    2    0    0    0    0    0    0    0    4    7    4    9    5    7    38

END OF RAINFALL DATA.
  73 RAINFALL DAYS PROCESSED ENCOMPASSING   219 DAYS   1 YEARS  OF RECORD.
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                                              URBAN WATERSHED DATA
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                          NAMEWS                  MXLG   EXPTE    REFF
                  WEST TORONTO                      3    4.600    0.800

                         AREA   CPERV    CUMP     RFU      IQU      DVU   DVUMX     WV
                      2300.00    0.30    0.80    0.90        0      0.0     0.0    0.0

          DEPRESSION STORAGE   INCHES     DAILY EVAPORATION RATES FOR EACH MONTH, JAN-DEC IN INCHES/DAY
                     0.050                0.04 0.04 0.04 0.30 0.30 0.40 0.60 0.48 0.40 0.20 0.04 0.04


                                      INPUT DATA DESCRIBING LAND USE AND POLLUTANTS

          LNDUSE    PRCNT     FIMP    STLEN   NCLEAN      DD          POUNDS POLLUTANT PER 100LB DD
                                                                   SUSP       SETL       BOD          N          PO4
          SINGLE     60.0     54.0    275.0        7     0.0       0.0        0.0        0.0        0.0        0.0
          MULTPL     20.0     54.0    430.0        3     0.0       0.0        0.0        0.0        0.0        0.0
          INDSTL     20.0     54.0    100.0        1     0.0       0.0        0.0        0.0        0.0        0.0

                            COMPUTED RUNOFF COEFFICIENT FOR WATERSHED IS0.57000


                            FRACTION OF URBAN WATERSHED THAT IS IMPERVIOUS IS0.5400


                                 LAND USE AND POLLUTANT DATA WITH DEFAULT VALUES ADDED

    LAND USE           PRCNT OF   PRCNT    GUTTERS  SWEEPING      DD RATE   ********** LBS POLLUTANT/100LBS DD **********
                       LND AREA   IMPERV    FT/AC  INTRVL, DYS    LBS/DAY      SUSP       SETL       BOD         N        PO4
      SINGLE             60.0      54.0     275.0       7         2656.5     11.100      1.100      0.500      0.048      0.005
      MULTPL             20.0      54.0     430.0       3         4549.4      8.000      0.800      0.360      0.061      0.005
      INDSTL             20.0      54.0     100.0       1         2116.0      6.700      0.700      0.300      0.043      0.003
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PAGE    1                                                             PARKSIDE DRIVE OVERFLOW
                                                                       QUANTITY ANALYSIS
TREATMENT RATE    0.0300 IN/HR,     69.6 CFS,     44.967 MGD                                                  OLD WESTON RD RAINGAUGE
STORAGE CAPACITY  0.0160 INCHES,     3.1 AC-FT,    0.999 MG                                                     WEST TORONTO

EVENT ---D A T E--- HRS NO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 *3 *****4 ****5 ***6 *****7 ****7A *****8 ****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22

    1   73  4 27 16    784     8    8   0.52   0.30      0     8  0.01   1   3   3  0.06  0.06    43  0.60  0.6  2.9  4.7  1.7  2.4
    2   73  5  1 10     80     2    2   0.12   0.07      1     3  0.01   2   1   1  0.01  0.01     5  0.09  0.6  1.5  1.5  0.6  0.6
    3   73  5  2 21     32     1    1   0.14   0.06      1     2  0.01   3   1   1  0.01  0.01     2  0.04  0.5  0.5  1.5  0.5  0.5
    4   73  5  8 12    133     4    4   0.26   0.13      0     4  0.01   4   2   1  0.02  0.02     5  0.11  0.7  1.5  2.5  1.0  1.0
    5   73  5  8 19      3     2    2   0.07   0.04      0     2  0.0           1  NO OVERFLOW      3  0.06  0.5  0.5  0.5  0.5  0.5
    6   73  5  8 22      1     2    2   0.11   0.06      0     2  0.01   5   1   1  0.0   0.0      2  0.05  0.5  0.5  0.5  0.5  0.5
    7   73  5 10 19     43     5    4   0.89   0.47      1     6  0.01   6   1   4  0.32  0.29     6  0.15  0.6  2.5  2.5  1.3  1.3
    8   73  5 26  6    365     2    2   0.12   0.07      1     3  0.01   7   1   1  0.0   0.0     14  0.17  0.6  1.5  1.5  0.8  0.8
    9   73  5 28  5     44     6    6   0.62   0.35      0     6  0.01   8   1   3  0.18  0.18     8  0.18  0.7  1.5  1.5  1.0  1.0
   10   73  5 31  5     66     2    2   0.12   0.07      1     3  0.01   9   1   1  0.0   0.0      6  0.08  0.5  1.5  1.5  0.9  0.9
   11   73  6 18  2    426     2    2   0.30   0.16      1     3  0.01  10   1   2  0.08  0.08    10  0.14  0.5  1.5  1.5  1.0  1.0
   12   73  6 22 14    105     1    1   0.29   0.16      1     2  0.01  11   1   1  0.11  0.11     2  0.04  0.5  0.5  0.5  0.5  0.5
   13   73  6 24  6     38     2    2   0.11   0.07      1     3  0.0           2  NO OVERFLOW      4  0.07  0.5  1.4  1.4  1.0  1.0
   14   73  6 28 16    103     3    3   0.62   0.33      0     3  0.01  12   1   2  0.24  0.24     6  0.11  0.5  1.5  1.5  1.0  1.0
   15   73  7 13 22    363     1    1   0.12   0.04      1     2  0.01           1  NO OVERFLOW      5  0.09  0.5  0.5  0.5  0.5  0.5
   16   73  7 25  4    268     3    3   0.65   0.35      1     4  0.01  13   1   3  0.23  0.23     5  0.12  0.5  2.5  2.5  1.5  1.5
   17   73  7 26 19     35     1    1   0.26   0.13      1     2  0.01  14   1   1  0.07  0.07     4  0.06  0.5  0.5  0.5  0.5  0.5
   18   73  7 26 22      1     1    1   0.11   0.04      1     2  0.0           1  NO OVERFLOW      2  0.03  0.5  0.5  0.5  0.5  0.5
   19   73  8  1  1    121     5    5   1.61   0.89      1     6  0.01  15   1   4  0.74  0.72     9  0.18  0.8  4.5  4.5  2.1  2.1
   20   73  8 10 17    226     1    1   0.10   0.05      1     2  0.01  16   1   1  0.0   0.0      3  0.05  0.5  0.5  0.5  0.5  0.5
   21   73  9 17 19    912     2    2   0.08   0.05      0     2  0.0           1  NO OVERFLOW      6  0.09  0.5  0.5  0.5  0.5  0.5
   22   73  9 17 23      2     2    2   0.18   0.09      1     3  0.01  17   2   1  0.01  0.01     4  0.10  0.5  1.3  1.3  0.9  0.9
   23   73  9 22  4     98     2    2   0.10   0.06      0     2  0.01  18   1   1  0.01  0.01     5  0.08  0.5  0.5  0.5  0.5  0.5
   24   73  9 22  7      1     3    3   0.38   0.21      1     4  0.01  19   1   2  0.11  0.11     4  0.09  0.7  2.5  2.5  1.1  1.1
   25   73  9 22 14      3     1    1   0.14   0.05      1     2  0.01  20   1   1  0.0   0.0      2  0.04  0.5  0.5  0.5  0.5  0.5
   26   73  9 23  9     17     3    3   0.33   0.16      1     4  0.01  21   2   2  0.05  0.05     4  0.10  0.5  2.3  2.3  1.4  1.4
   27   73 10  2  5    206     2    2   0.16   0.09      1     3  0.01  22   1   2  0.01  0.01     5  0.08  0.5  1.5  1.5  1.0  1.0
   28   73 10  2 21     13     2    2   0.31   0.18      1     3  0.01  23   1   1  0.11  0.11     5  0.08  0.6  1.5  1.5  0.8  0.8
   29   73 10 13 17    257     3    3   0.16   0.09      0     3  0.01  24   1   1  0.01  0.01     4  0.08  0.6  1.5  1.5  0.8  0.8
   30   73 10 28 18    358     7    7   0.61   0.35      0     7  0.01  25   1   5  0.15  0.08    12  0.25  0.7  5.5  5.5  2.7  2.7
   31   73 10 29  4      3     5    5   0.30   0.16      0     5  0.01  26   1   3  0.02  0.02     5  0.13  0.7  3.5  3.5  1.7  1.7
   32   73 10 29 14      5    11   11   0.67   0.50      0    11  0.01  27   3   6  0.19  0.03    12  0.31  0.9  6.6  6.6  3.4  3.4
   33   73 10 30  2      1     2    2   0.15   0.08      0     2  0.01  28   1   1  0.02  0.02     2  0.05  0.5  0.5  0.5  0.5  0.5
   34   73 10 30 12      8     3    3   0.14   0.08      0     3  0.0           2  NO OVERFLOW      9  0.16  0.5  0.6  0.6  0.6  0.6
   35   73 10 31 22     31     3    3   0.18   0.11      1     4  0.01  29   1   2  0.0   0.0     12  0.23  0.9  1.5  1.5  0.5  0.7

AVE OF    35 EVENTS   104.8** 3.0  3.0   0.33   0.17    0.6   3.6  0.03      1.3*                    6.7  0.13  1.2  1.7  1.8  1.0  1.0
AVE OF    29 OVRFLW EVENTS    3.2  3.2   0.37   0.20    0.6   3.9  9.29*     1.2 2.0  0.10  0.09    7.1  0.14  0.6  1.9  2.0  1.1  1.1

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING  2 DRY PERIODS


               AVERAGE ANNUAL STATISTICS FOR  1 YEARS OF RECORD FOR THE PERIOD BEGINNING 730401 AND ENDING 731031
               ---------------------------------------------------------------------------------------------------


               NUMBER OF EVENTS        35.0
NUMBER OF OVERFLOWS     29.0

                                        INCHES
                                        ------

TOTAL PRECIPITATION ON WATERSHED     16.73

TOTAL RUNOFF FROM WATERSHED           7.36     FRACTION OF RAINFALL  0.44

OVERFLOW TO RECEIVING WATER           2.89     FRACTION OF RAINFALL  0.17,  OF RUNOFF  0.39

INITIAL OVERFLOW TO RECIEVING WATER  2.63     FRACTION OF RAINFALL  0.16,  OF RUNOFF  0.36
```

```
PAGE     1                                                  PARKSIDE DRIVE OVERFLOW
                                                              QUANTITY ANALYSIS
TREATMENT RATE      0.0300 IN/HR,      69.6 CFS,     44.967 MGD                                   OLD WESTON RD RAINGAUGE
STORAGE CAPACITY    0.0220 INCHES,      4.2 AC-FT,    1.374 MG                                         WEST TORONTO

EVENT ---D A T E--- HRS TO -R A I N F A L L- RUNOFF HRS TO --STORAGE-- ----O V E R F L O W---- ---TREATMENT---- --AGE OF STORAGE---
      YEAR MO DY HR STORAG DURTN  HRS QUANTY INCHES  EMPTY DURTN   MAX  NO  ST DUR WASTE INITL  HRS  QANTY AGE1 AGE2 AGE3 AGE4 AGE5
****1 *********2 **3 *****4 ****5 ***6 *****7 ****7A *****8 *****9 ***10 *11 *12 *13 ***14 ***15 ***16 ***17 **18 **19 **20 **21 **22

    1    73  4 27 18    784     6     8   0.52   0.30      0     8  0.02   1   5   2  0.05  0.05   43  0.61  0.6  2.9  4.1  1.7  2.3
    2    73  5  1 10     80     2     2   0.12   0.07      1     3  0.02   2   1   1  0.0   0.0     5  0.09  0.6  1.5  1.5  0.8  0.8
    3    73  5  2 21     32     1     1   0.14   0.06      1     2  0.02   3   1   1  0.0   0.0     2  0.05  0.5  0.5  0.5  0.5  0.5
    4    73  5  8 12    135     4     4   0.26   0.13      0     4  0.02   4   2   1  0.02  0.02    5  0.11  0.7  1.5  2.5  1.0  1.2
    5    73  5  8 19      3     2     2   0.07   0.04      0     2  0.0        1  NO OVERFLOW       3  0.06  0.5  0.5  0.5  0.5  0.5
    6    73  5  8 22      1     2     2   0.11   0.06      0     2  0.01       1  NO OVERFLOW       2  0.05  0.5  0.5  0.5  0.5  0.5
    7    73  5 10 19     43     5     4   0.89   0.47      1     6  0.02   5   1   4  0.30  0.28    6  0.16  0.6  2.5  2.5  1.3  1.3
    8    73  5 26  6    365     2     2   0.12   0.07      1     3  0.02       1  NO OVERFLOW      14  0.18  0.6  1.5  1.5  0.9  0.9
    9    73  5 28  5     44     6     6   0.62   0.35      0     6  0.02   6   1   3  0.17  0.17    8  0.19  0.7  1.5  1.5  1.0  1.0
   10    73  5 31  5     66     2     2   0.12   0.07      1     3  0.01       1  NO OVERFLOW       6  0.08  0.5  1.5  1.5  0.9  0.9
   11    73  6 18  2    420     2     2   0.30   0.16      1     3  0.02   7   1   2  0.07  0.07   10  0.15  0.5  1.5  1.5  1.0  1.0
   12    73  6 22 14    105     1     1   0.29   0.16      1     2  0.02   8   1   1  0.10  0.10    2  0.05  0.5  0.5  0.5  0.5  0.5
   13    73  6 24  6     38     2     2   0.11   0.07      1     3  0.0        2  NO OVERFLOW       4  0.07  0.5  1.4  1.4  1.0  1.0
   14    73  6 28 16    103     3     3   0.62   0.33      0     3  0.02   9   1   2  0.23  0.23    6  0.11  0.5  1.5  1.5  1.0  1.0
   15    73  7 13 22    363     1     1   0.12   0.04      1     2  0.01       1  NO OVERFLOW       5  0.09  0.5  0.5  0.5  0.5  0.5
   16    73  7 25  4    268     3     3   0.65   0.35      1     4  0.02  10   2   2  0.23  0.23    5  0.13  0.5  2.3  2.3  1.4  1.4
   17    73  7 26 19     35     1     1   0.26   0.13      1     2  0.02  11   1   1  0.07  0.07    4  0.07  0.5  0.5  0.5  0.5  0.5
   18    73  7 26 22      1     1     1   0.11   0.04      1     2  0.0        1  NO OVERFLOW       2  0.03  0.5  0.5  0.5  0.5  0.5
   19    73  8  1  1    121     5     5   1.61   0.89      1     6  0.02  12   1   4  0.73  0.71    9  0.19  0.8  4.5  4.5  2.2  2.2
   20    73  8 10 17    226     1     1   0.10   0.05      1     2  0.02       1  NO OVERFLOW       3  0.05  0.5  0.5  0.5  0.5  0.5
   [illegible]                                     0.05      0     2  0.0        1  NO OVERFLOW       6  0.09  0.5  0.5  0.5  0.5  0.5
   22    73  9 17 23      2     2     2   0.18   0.09      1     3  0.02  13   2   1  0.0   0.0     4  0.10  0.5  1.1  1.1  0.9  0.9
   23    73  9 22  4     98     2     2   0.10   0.06      0     2  0.02  14   1   1  0.0   0.0     5  0.09  0.5  0.5  0.5  0.5  0.5
   24    73  9 22  7      1     3     3   0.38   0.21      1     4  0.02  15   1   2  0.11  0.11    4  0.09  0.7  2.5  2.5  1.2  1.2
   25    73  9 22 14      3     1     1   0.14   0.05      1     2  0.02  16   1   1  0.0   0.0     2  0.05  0.5  0.5  0.5  0.5  0.5
   26    73  9 23  9     17     3     3   0.33   0.16      1     4  0.02  17   2   2  0.04  0.04    4  0.11  0.5  2.1  2.1  1.3  1.3
   27    73 10  2  5    208     2     2   0.16   0.09      1     3  0.02  18   2   1  0.01  0.01    5  0.09  0.5  1.5  1.5  1.0  1.0
   28    73 10  2 21     13     2     2   0.31   0.18      1     3  0.02  19   1   1  0.10  0.10    5  0.09  0.6  1.5  1.5  0.9  0.9
   29    73 10 13 17    257     3     3   0.16   0.09      0     3  0.02  20   1   1  0.01  0.01    4  0.08  0.6  1.5  1.5  0.9  0.9
   30    73 10 28 18    358     7     7   0.61   0.35      0     7  0.02  21   2   4  0.15  0.12   12  0.25  0.7  5.0  5.5  2.7  2.7
   31    73 10 29  4      3     5     5   0.30   0.16      0     5  0.02  22   1   3  0.01  0.01    5  0.14  0.7  3.5  3.5  1.8  1.8
   32    73 10 29 14      5    11    11   0.87   0.50      0    11  0.02  23   4   5  0.18  0.11   12  0.32  0.9  6.1  6.1  3.3  3.3
   33    73 10 30  2      1     2     2   0.15   0.08      1     3  0.02  24   1   1  0.02  0.02    3  0.06  0.7  1.5  1.5  0.6  0.6
   34    73 10 30 12      7     3     3   0.14   0.08      0     3  0.0        2  NO OVERFLOW       9  0.16  0.5  0.6  0.6  0.6  0.6
   35    73 10 31 22     31     3     3   0.18   0.11      1     4  0.01       3  NO OVERFLOW      12  0.23  0.9  1.5  1.5  0.5  0.7

AVE OF    35 EVENTS     111.5** 3.0   3.0   0.33   0.17    0.6   3.6  0.04       1.4*               6.7  0.13  1.2  1.7  1.7  1.0  1.0
AVE OF    24 OVRFLW EVENTS      3.5   3.5   0.42   0.23    0.6   4.1  7.37*      1.5 2.0  0.11  0.11  7.1  0.15  0.6  2.0  2.1  1.2  1.2

* NON-OVERFLOW EVENTS ONLY.
**EXCLUDING  4 DRY PERIODS


              AVERAGE ANNUAL STATISTICS FOR  1 YEARS OF RECORD FOR THE PERIOD BEGINNING 730401 AND ENDING 731031
              ---------------------------------------------------------------------------------------------------


              NUMBER OF EVENTS       35.0
NUMBER OF OVERFLOWS     24.0

                                        INCHES
                                        ------

TOTAL PRECIPITATION ON WATERSHED         16.73

TOTAL RUNOFF FROM WATERSHED               7.36      FRACTION OF RAINFALL  0.44

OVERFLOW TO RECEIVING WATER               2.72      FRACTION OF RAINFALL  0.16,  OF RUNOFF   0.37

INITIAL OVERFLOW TO RECIEVING WATER       2.58      FRACTION OF RAINFALL  0.15,  OF RUNOFF   0.35
```

```
DEFINITIONS OF QUANTITY COLUMN HEADINGS
---------------------------------------

 1  EVENT     SEQUENCING NUMBER.
 2  DATE      DATE THIS EVENT BEGAN.
 3  HR        NUMBER OF HOURS PAST MIDNIGHT THIS EVENT BEGAN.
 4  HRS NO
    STORAG    NUMBER OF HOURS SINCE END OF LAST EVENT, EXCLUDING SUMMER  MORE THAN,  480 HOURS .

 5  DURTN     DURATION OF  STORM FROM FIRST HOUR OF RAIN TO LAST HOUR OF RAIN.
 6  HRS       NUMBER OF HOURS IN WHICH RAINFALL OCCURRED DURING EVENT.
 7  QUANTY    AMOUNT OF RAINFALL DURING THE EVENT IN INCHES.
7A  RUNOFF
    INCHES     RUNOFF DURING EVENT IN INCHES.
 8  HRS TO
    EMPTY     NUMBER OF HOURS FROM LAST RAINFALL TO END OF EVENT.
 9  DURTN     TOTAL NUMBER OF HOURS STORAGE WAS UTILIZED.  IE, LENGTH OF THE EVENT.
10  MAX       MAXIMUM AMOUNT OF STORAGE UTILIZED, IN INCHES.

11  NO        OVERFLOW EVENT SEQUENCING NUMBER.
12  ST        NUMBER OF HOURS ELAPSED BEFORE OVERFLOW STARTED.  OR, IF NO OVERFLOW, HOUR OF MAXIMUM STORAGE.
13  DUR       NUMBER OF HOURS IN WHICH OVERFLOW OCCURED.
14  WASTE     QUANTITY OF WATER RELEASED UNTREATED, IN INCHES.
15  INITL     QUANTITY OF WATER RELEASED UNTREATED DURING THE FIRST  3 HOURS OF OVERFLOW.

16  HRS       NUMBER OF HOURS WATER WAS TREATED DURING THE PRESENT EVENT AND SINCE THE PREVIOUS EVENT.
17  QANTY     QUANTITY OF WATER TREATED DURING THE EVENT AND SINCE THE PREVIOUS EVENT.
18  AGE1      AVERAGE AGE  HOURS  OF TREATED RUNOFF.
19  AGE2      MAXIMUM AGE  HOURS  OF STORAGE ON FIRST IN, FIRST OUT BASIS.
20  AGE3      MAXIMUM AGE  HOURS  OF STORAGE ON FIRST IN, LAST OUT BASIS.
21  AGE4      QUANTITY WEIGHTED AVERAGE AGE  HRS  OF STORAGE ON FIRST IN, FIRST OUT BASIS.
22  AGE5      QUANTITY WEIGHTED AVERAGE AGE  HRS  OG STORAGE ON FIRST IN, LAST OUT BASIS.
```

```
PAGE      1                                                                  PARKSIDE DRIVE OVERFLOW
                                                                           POLLUTOGRAPH FOR EVENT
TREATMENT RATE      0.0300 IN/HR,      69.6 CFS,      44.967 MGD                                                    OLD WESTON RD RAINGAUGE
STORAGE CAPACITY    0.0160 INCHES,      5.1 AC-FT,     0.999 MG                                                          WEST TORONTO

                                                                     **RUNOFF POLLUTANT LOAD, IN LBS/HR**       ** AVE CONCENTRATION, IN MG/L ******
EVENT YR MO DY HR T O  RAINFALL RUNOFF CFS-OFF                        SUSP     SETL      BOD       N     PO4     SUSP     SETL      BOD       N      PO4

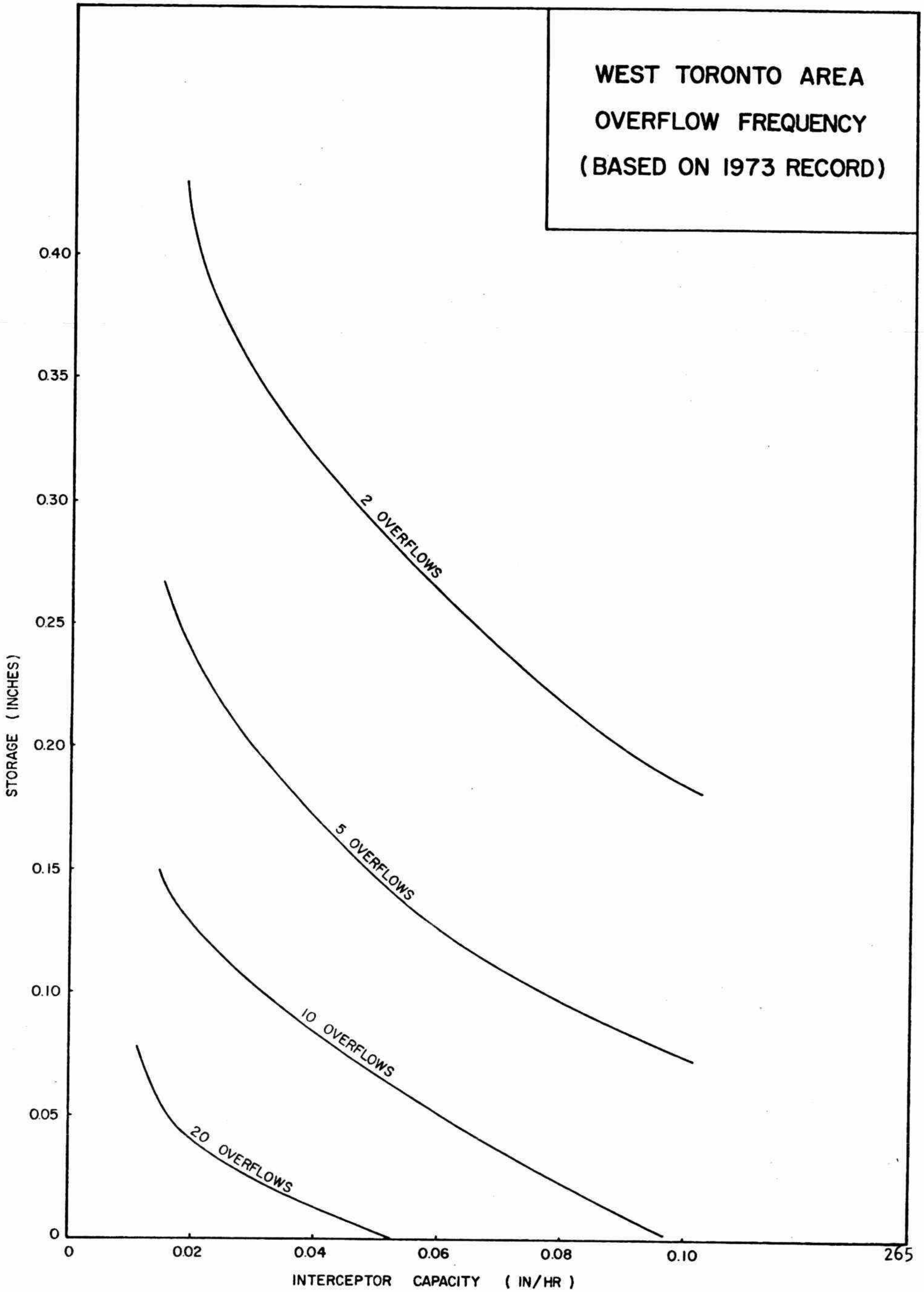
    7 73  5 10 19   1      0.58   0.30   707.2                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
    7 73  5 10 21   3      0.15   0.08   185.7                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
    7 73  5 10 22   4      0.05   0.03    71.4                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
    7 73  5 10 23   5      0.10   0.06   130.9                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0


   12 73  6 22 14   1      0.30   0.16   374.1                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0


   19 73  8  1  1   1      0.70   0.37   861.9                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
   19 73  8  1  2   2      0.70   0.40   928.0                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
   19 73  8  1  3   3      0.10   0.06   130.9                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
   19 73  8  1  4   4      0.09   0.05   119.0                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
   19 73  8  1  5   5      0.03   0.02    35.7                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0


   26 73  9 23  9   1      0.13   0.04   100.5                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
   26 73  9 23 10   2      0.15   0.09   202.3                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
   26 73  9 23 11   3      0.05   0.03    71.4                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0


   28 73 10  2 21   1      0.28   0.16   368.8                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
   28 73 10  2 22   2      0.04   0.02    47.6                        0.0      0.0       0.0      0.0    0.0     0.0      0.0       0.0      0.0     0.0
```


WEST TORONTO AREA
OVERFLOW FREQUENCY
(BASED ON 1973 RECORD)
STORAGE (INCHES)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
0
0.02
0.04
0.06
0.08
0.10
INTERCEPTOR CAPACITY (IN/HR)
2 OVERFLOWS
5 OVERFLOWS
10 OVERFLOWS
20 OVERFLOWS

INPUT DATA DESCRIPTION

FOR

SWMM

EXECUTIVE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
1			I/O tape/disk assignments.		
	20I4	1-4	Input tape assignment for first block to be run.	JIN(1)	0
		5-8	Output tape assignment for first block to be run.	JOUT(1)	0
		9-12	Input tape assignment for second block to be run (usually the same as the output tape from first block).	JIN(2)	0
		13-16	Output tape for second block to be run.	JOUT(2)	0
		⋮		⋮	
		77-80	Output tape for tenth block to be run.	JOUT(10)	0
2			Scratch tape-disk assignments.		
	5I4	1-4	First scratch tape assignment.	NSCRAT(1)	0
		5-8	Second scratch tape assignment.	NSCRAT(2)	0
		9-12	Third scratch tape assignment.	NSCRAT(3)	0
		13-16	Fourth scratch tape assignment.	NSCRAT(4)	0
		17-20	Fifth scratch tape assignment.	NSCRAT(5)	0
			REPEAT CARD 6 FOR EACH BLOCK TO BE CALLED.		
3			Control cards indicating which blocks in the program are to be called.		
	3A4	1-12	Name of block to be called.[a]	CNAME	None

---

[a] Names must start in column 1. All blocks may be called more than once if overlay is not used or if overlay is used one or more blocks may be repeated if overlay is set up for this. See Section 2, Initial Job Set-Up.

NOTE: All non-decimal numbers must be right-adjusted.

EXECUTIVE BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
			CNAME = RUNOFF for Runoff Block, = TRANSPORT for Transport Block, = RECEIVING for Receiving Water Block = STORAGE for Storage Block, = COMBINE for Combine Block, = GRAPH for GRAPH subroutine, = ENDPROGRAM for ending the storm water simulation.		
			INSERT THESE CARDS AFTER EACH CNAME = GRAPH IN CARD GROUP 3.		
4			Control card.		
	4I5	1-5	Tape/disk (logical unit) assignment where graph information is stored.	NTAPE	None
		6-10	Number of curves of a graph. (maximum = 5)[a]	NPCV	5
		11-15	Number of pollutants to be plotted.	NQP	0
		16-20	Number of inlets to be plotted. (If NPLOT = 0 plots all curves on file)	NPLOT	0
			IF NPLOT = 0 DELETE THIS CARD.		
5			Inlet selection card.		
	16I5	1-5	First inlet number to be plotted.	IPLOT(1)	None
		6-10	Second inlet number to be plotted.	IPLOT(2)	None
		. . . .		. . . .	
		.	Last inlet number to be plotted.	IPLOT(NPLOT)	None

---

[a] This refers to the number of different inlets (curves) that will be plotted on one graph; e.g. if NPCV = 3, hydrographs, say, from three inlets will be overlayed on one graph

EXECUTIVE BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
6			Title card.		
	18A4	1-72	Title printed with the plots.	TITL	None
7			Horizontal axis label.		
	20A4	1-80	Horizontal axis label.	HRIZ	None
			REPEAT NQP + 1 TIMES.		
8			Vertical axis label.[a]		
	2A4	1-8	Line 1 of vertical axis label.	VERT(1)	None
		9-16	Line 2 of vertical axis label.	VERT(2)	None
	3A4	17-28	Line 3 of vemtical axis label.	VERT(3)	None

[a] The first plot to be printed is a flow hydrograph, the second is BOD, the third is SS, and the last is coliform.

RUNOFF BLOCK CARD DATA

Card Group	Format	Card Columns	Description	Variable Name	Default Value
1	20A4		Title cards: two cards with TITLE heading to be printed on output.		Blanks
2			Control card: one card		
	2I5	1-5	Basin identification number	BASIN	0
		6-10	Number of time-steps to be calculated (Maximum = 150)	NSTEP	None
	I3	11-13	Hour of start of storm (24-hour clock)	NHR	0
	I2	14-15	Minutes of start of storm	NMN	0
	F5.0	16-20	Integration period (time step), min.	DELT	None
	I5	21-25	Number of hyetographs (rain gauges)	NRGAG	None
	F5.0	26-30	Percent of impervious area with zero detention (immediate runoff)	PCTZER	25.0
	I5	31-35	IROS = 1, Erosion for subcatchment is to be molded	IROS	0
	F5.0	36-40	If IROS = 1, Highest average 30-minute rainfall intensity, in/hr.	RAINIT	0.0
	I5	40-45	If ISNO ≠ 0 Snowmelt is called	ISNO	0
3			Rainfall control card.		
	I5	1-5	Number of data points for each hyetograph (maximum = 200)	NHISTO	None
	F5.0	6-10	Time interval between values min.	THISTO	None

Card Group	Format	Card Columns	Description	Variable Name	Default Value
Note:	The Runoff block requires only one scratch data-set. All non-decimal numbers must be right-justified.				
			REPEAT CARD GROUP 4 FOR EACH HYETOGRAPH.		
4			Rainfall hyetograph cards: 10 intervals per card (Maximum number of values = 200).		
	10F5.0	1-5	Rainfall intensity, first interval, in/hr.	RAIN(1)	None
		6-10	Rainfall intensity, second interval, in/hr.	RAIN(2)	None
		11-15	Rainfall intensity, third interval, in/hr.	RAIN(3)	None
		16-20	Rainfall intensity, fourth interval, in/hr.	RAIN(4)	None
		⋮		⋮	
4A			Snow Control Card Include card 4A if ISNO ≠ 0 on card 2		
	4F10.0	1-10	Degree hour melt rate. If this field is zero or blank the DHMR method is not used for snow melt, snow melt is calculated using wind, elevt., and rain.	DHMR	0
		11-20	Snow melt base temperature	TBASE	None
		21-30	Wind speed (MPH)	WIND	0
		31-40	Elevation of area (in thousands of feet ie 1000 ft. = 1.0)	ELEVT	0

Card Group	Format	Card Columns	Description	Variable Name	Default Value
4B			**TEMPERATURE AT EACH TIME STEP** **Include only if ISNO ≠ 0 on card 2**		
	16F5.0	**1-5**	**Temperature in degrees fahrenheit**	**TEMP(1)**	**0**
		6-10		**TEMP(2)**	
		.		.	
		.		.	
		.		.	
		75-80		**TEMP(NSTEP)**	
			REPEAT CARD 5 FOR EACH GUTTER/PIPE.		
5			**Gutter/pipe cards: one card per gutter/pipe (if none, leave out) (maximum number = 200).**		
	I10	1-10	Gutter/pipe number.[b]	NAMEG	None
	2I5	11-15	Gutter or inlet number for drainage.[b]	NGTO	None
		16-20	= 1 for gutter, = 2 for pipe.	NP	None
	7F8.0	21-28	Bottom width of gutter or pipe diameter, ft.	GWIDTH=G1	None
		29-36	Length of gutter, ft.	GLEN =G2	None
		37-44	Invert slope, ft/ft.	GSLOPE=G3	None

---

[a] Problems may occur when zero rainfall occurs several time-steps before the actual start of the rainfall (the computer underflows).

[b] Numbers may be arbitrarily chosen. However, if inlet number is to correspond to inlet manhole for Transport Block, it must be ⩽ 1000. The maximum total number of inlets must be ⩽ 50 for input to Receiving or ⩽ 70 for input to Transport.

Card Group	Format	Card Columns	Description	Variable Name	Default Value
		45-52	Left-hand side slope, ft/ft.	GS1 =G4	None
		53-60	Right-hand side slope, ft/ft.	GS2 =G5	None
		61-68	Manning's coefficient.	GN =G6	0.018
		69-76	Depth in gutter when full, in.	DFULL=G7	10.0
6			Blank card to terminate gutter cards: one card (must always be included).		
			REPEAT CARD 7 FOR EACH SUBCATCHMENT.		
7	3I5	1-5	Hyetograph number (based on the order in which they are read in).	JK	1
		6-10	Subcatchment number.[a]	NAMEW	None
		11-15	Gutter or manhole number for drainage.[a,b]	NGTO	None
	10F5.0	16-20	Width of subcatchment, ft. This term actually refers to the physical width of overland flow in the subcatchment and may be obtained as illustrated under Instructions for Data Preparation.[c]	WWIDTH=W1	None

[a] Numbers may be arbitrarily chosen. However, if inlet number is to correspond to inlet manhole for Transport Block, it must be ≤ 1000. The maximum total number of inlets must be ≤ 70 for input to Transport or ≤ 50 for input to Receiving.

[b] Need one inlet or gutter/pipe for each subcatchment basin.

[c] As an approximation, twice the length of the principal drainage conduit through the subcatchment may be used.

RUNOFF BLOCK CARD DATA (Cont'd)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
		21-25	Area of subcatchment, acres.	WAREA =W2	None
		26-30	Percent imperviousness of subcatchment.	PCIMP =W3	0.001
		31-35	Ground slope, ft/ft.	WSLOPE=W4	0.030
		36-40	Impervious area. Resistance	W5 =W5	0.013
		41-45	Pervious area. Factor. (Manning's n)	W6 =W6	0.250
		46-50	Impervious area. Retention storage, in	WSTORE=W7	0.062
		51.55	Pervious area	WSTORE=W8	0.184
		56-60	Maximum infiltration rate, in/hr.	WLMAX =W9	3.00
		61-65	Minimum infiltration rate, in/hr.	WLMIN =W10	0.52
	F10.5	66-75	Decay rate of infiltration in Horton's equation, 1/sec	DECAY =W11	0.00115
8			Blank card to terminate subcatchment cards: one card.		
8A			SNOW SUBCATCHMENT DESCRIPTIONS		
			Include only if ISNO ≠ 0 on card 2		
	I5	1-5	Subcatchment number (all subcatchments in card type 7 must be included. They must both be in the same order) If JK = -1 the rates for W12 - W19 are changed. If JK = -2 the default values are changed.	JK	0
	9F5.0	6-10	Percent of Impervious Area covered by snow	W12	0
		11-15	Water equivalent of snow on area W12 (in.)	W13	0
		16-20	Percent of pervious area covered by snow	W14	0

RUNOFF BLOCK CARD DATA (Cont'd)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
		21-25	Water equivalent of snow on area W14 (in.)	W15	0
		26-30	Ratio of free water holding capacity to water equivalent of snow on W12	W16A	.03
		31-35	Ratio of free water holding capacity to water equivalent on W14	W16B	.03
		36-40	Ratio of initial free water to water equivalent	W17	0
		41-45	Mannings N for area W12	W18	.013
		46-50	Mannings N for area W14	W19	.25
9			SURFACE QUALITY CONTROL CARD		
	I10	1-10	Surface Quality NQS = 0, no quality modelled NQS = 1, quality to be modelled	NQS	0
			******** THE FOLLOWING PARAMETERS ******* ARE NEEDED ONLY IF NQS = 1:		
	2F10.0	11-20	Number of dry days prior to this storm in which the accumulative rainfall is less than 1.0 inch.	DRYDAY	0.0
		21-30	Street cleaning frequency, days	CLFREQ	0.0
	I10	31-40	Number of Street sweeper passes	NPASS	0
	2F10.0	41-50	Catchbasin Storage volume, ft^3.	CBVOL	0.0
		51-60	Concentration of BOD (mg/l), of the stored water in each catchbasin (100 recommended)	CBFACT(4)	0.0

Card Group	Format	Card Columns	Description	Variable Name	Default Value
	I5	61-65	Method for calculating suspended solids ISS = 0, same as for all other pollutants (Vol. I). ISS = 1, special technique. Same as in original Release 1 of the SWMM.	ISS	0
	I5	66-70	If IABLK ≠ 0 calls initialize routine =1 reads DDFACT =2 reads DDFACT & QFACT & PNAME	IABLK	0
			ABLK DEFAULTS		
9A			DDFACT VALUES		
			Include if IABLK ≠ 0 on card 9		
	5F10.0	1-10	Dust and dirt factor land type 1	DDFACT(1)	0
		11-20	Dust and dirt factor land type 2	DDFACT(1)	0
		11-20	Dust and dirt factor land type 3	DDFACT(3)	0
		11-20	Dust and dirt factor land type 4	DDFACT(4)	0
		41-50	Dust and dirt factor land type 5	DDFACT(5)	0
9B			Include cards 9B, C, if IABLK ≠ 0 or 1 on card 9		
	I10	1-10	Number of pollutants for quality factors	NQS	0
9C			Repeat card 9C for each pollutant		
	6F10.0	1-10	Quality Factor for Pollutant 1 for land type 1	QFACT(1,1)	
		11-20	Quality Factor for Pollutant 1 for land type 2	QFACT(2,1)	
		21-30	Quality Factor for Pollutant 1 for land type 3	QFACT(3,1)	
		31-40	Quality Factor for Pollutant 1 for land type 4	QFACT(4,1)	
		41-50	Quality Factor for Pollutant 1 for land type 5	QFACT(5,1)	

RUNOFF BLOCK CARD DATA (Cont'd)

Card Group	Format	Card Columns	Description	Variable Name	Default Value
		51-60	Name of Pollutant 1	PNAME(NQS)	
10			**Erosion card.** **If IROS = 0 on Card 2, SKIP to CARD 11.** **REPEAT CARD 10 FOR EACH SUBCATCHMENT.**		
	I5	1-5	**Subcatchment number (must be read in same order as Card Group 7)**	N	None
	5F5.0	6-10	**Area of subcatchment subject to erosion, acres.**	ERODAR(N)	0.0
		11-15	**Flow distance in feet from point of origin of overland flow over erodable area to point at which runoff enters gutter or manhole.**	ERLEN(N)	0.0
		16-20	Soil factor 'K'.[a]	SOILF(N)	0.0
		21-25	Cropping management factor 'C'.[b]	CROPMF(N)	0.0
		26-30	Control practice factor 'P'.[b]	CONTPF(N)	0.0
11			SUBCATCHMENT SURFACE QUALITY DATA CARDS (one card per subcatchment and must be read in the same order as Card Group 7). If NQS = 0, skip to Card 12.		
	5X	1-5	Not used.		
	2I5	6-10	Subcatchment number	N	None

[a] See instructions for data preparation

[b] See instructions for data preparation and consult with local Soil Conservation Service or Agricultural Research Service experts.

Card Group	Format	Card Columns	Description	Variable Name	Default Value
		11-15	Land use classification. = 1, For single family residential, = 2, For multiple family residential, = 3, For commercial = 4, For industrial = 5, For undeveloped or park lands.	KL	5
	2F10.0	16-25	Number of catchbasins in subarea.	BA	None
		26-35	Total length of all gutters within subarea, hundreds of feet.	GQ	None
		36-45	Total pounds of salt applied in subarea	NACLBS	None
		46-55	Loading factor for lead in lbs. per 100 ft. of curb/day	PBRATE	None
12			GUTTER/INLET PRINT CONTROL: ONE CARD		
	2I5	1-5	Number of gutters/inlets for which flows are to be printed (maximum = 200).	NPRNT	0
		6-10	Number of time-steps between printings	INTERV	None
13			IF NPRNT = 0, SKIP CARD 13. GUTTER/INLET PRINT CARDS: 16 VALUES/CARD.		
	16I5	1-5	Gutter/inlet numbers for which flows and/or pollutants are to be printed.	IPRNT(1)	None
		6-10		IPRINT(2)	None
		11-15		IPRINT(3)	None
		.		.	
		.		.	
		.		.	
		.		.	
		.		IPRNT(NPRNT)	None

TRANSPORT BLOCK CARD DATA

Card group	Format	Card columns	Description	Variable name	Default value
1	16I5	5	Number of sewer cross-sectional shapes, in addition to the 12 program-supplied for which element routing parameters are to follow (maximum value = 3).	NKLASS	0
		10	Control parameter for printing out flow routing parameters for all shapes, *i.e.* KPRINT = 0 to suppress printing, KPRINT = 1 to allow printing (for all shapes, program-supplied and additional)	KPRINT	0
			DELETE CARD GROUPS 2 TO 10 IF NKLASS = 0.		
2			Name of user-supplied shapes.	NAME	
	20A4	1-16	16-letter name of shape 1.	NAME(I,14)	None
		17-32	16-letter name of shape 2.	NAME(I,15)	None
3			Number of values of DNORM to be supplied (maximum value = 51, minimum value = 2).	NN	
	16I5	4-5	Number of values for shape 1.	NN(14)	None
		9-10	Number of values for shape 2.	NN(15)	None

NOTE: All non-decimal numbers must be right-justified.

NOTE: Must always specify output tape or disk, two scratch data sets needed.

Card group	Format	Card columns	Description	Variable name	Default value
4			Number of values of QNORM to be read (maximum value = 51, minimum value = 2).	MM	
	16I5	4-5	Number of values for shape 1.	MM(14)	None
		9-10	Number of values for shape 2.	MM(15)	None
5			Value of A/A_f[a] corresponding to the maximum Q/Q_f[b] value for each shape.	ALFMAX	
	8F10.5	1-10	A/A_f value for shape 1.	ALFMAX(14)	None
		11-20	A/A_f value for shape 2.	ALFMAX(15)	None
6			Maximum Q/Q_f value for each shape.	PSIMAX	
	8F10.5	1-10	Maximum Q/Q_f value for shape 1.	PSIMAX(14)	None
		11-20	Maximum Q/Q_f value for shape 2.	PSIMAX(15)	None
7			Factor used to determine full flow area for each shape, *i.e.*, for use in AFULL = AFACT(GEOM1)^2.	AFACT	

---

[a] A/A_f = ANORM is the cross-sectional flow area divided by the cross-sectional flow area of the pipe running full. Tabular values of ANORM are generated in the program by dividing the ANORM axis (0.0 - 1.0) into NN-1 or MM-1 equal divisions.

[b] Q/Q_f = QNORM is the flow rate divided by the flow rate of the conduit flowing full.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
	8F10.5	1-10	Factor for shape 1.	AFACT(14)	None
		11-20	Factor for shape 2.	AFACT(15)	None
8			Factor used to determine full flow hydraulic radius for each shape, *i.e.*, for use in equation RADH = RFACT(GEOM1).	RFACT	
	8F10.5	1-10	Factor for shape 1.	RFACT(14)	None
		11-20	Factor for shape 2.	RFACT(15)	None
			REPEAT CARD GROUP 9 FOR EACH ADDED SHAPE.		
9			Input of tabular data (depth of flow, y, divided by total depth of conduit, y_f (y/y_f)) for each added shape corresponding to the NN-1 equal divisions of A/A_f of the conduit as given by NN on card group 3.[a]	DNORM	
	8F10.5	1-10	First value for y/y_f for shape 1.	DNORM(I,1)	None
		11-20	Second value for y/y_f for shape .	DNORM(I,2)	None
		.	.	.	
		.	.	.	
		.	.	.	
		.	Last value of y/y_f for shape 1.	DNORM(I,NN(I))	None
			(Total of NN(14)/8 + NN(15)/8 data cards)		

---

[a] y/y_f = DNORM is the depth of flow, y, divided by the maximum flow depth, y_f (*e.g.*, diameter of a circular conduit).

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
			REPEAT CARD GROUP 10 FOR EACH ADDED SHAPE.		
10			Input of tabular data (flow rate, Q, divided by the flow rate of the conduit running full, Q_f (Q/Q_f)). for each added shape corresponding to the MM-1 equal divisions of A/A_f of the conduit as given by MM on card group 4.	QNORM	
	8F10.5 .	1-10	First value of Q/Q_f for shape 1.	QNORM(I,1)	None
		11-20	Second value of Q/Q_f for shape 1.	QNORM(I,2)	None
		. . .	. . .	. . .	
		.	Last value for Q/Q_f for shape 1.	QNORM(I,MM(I))	None
			(Total of MM(14)/8 + MM(15)/8 data cards)		
11	20A4		Title card containing a one-line heading to be printed above output.	TITLE	Blanks
12			Execution control data.		
	16I5	3-5	Total number of sewer elements (maximum = 160).	NE	None
		8-10	Total number of time-steps (maximum = 150).[a]	NDT	None
		14-15	Total number of non-conduit elements into which there will be input hydrographs and pollutographs (maximum = 70, minimum = 1).[a]	NINPUT	None

---

[a] Not required if input is from tape or disk.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
		19-20	Total number of non-conduit elements at which input hydrographs and pollutographs are to be printed out (maximum = 20, minimum = 1).	NNYN	None
		24-25	Total number of non-conduit elements at which routed hydrographs and pollutographs are to be printed out (maximum = 20, minimum = 1).	NNPE	None
		30	Total number of non-conduit elements at which flow is to be transferred to a subsequent block by tape or disk (maximum = 5, minimum = 1).[a]	NOUTS	None
		35	Control parameter for program-generated error messages occurring in the execution of the flow routing scheme. These errors do not normally affect the program execution. NPRINT = 0 to suppress messages (recommended), NPRINT = 1 to print messages from ROUTE, NPRINT = 2 to print messages from ROUTE and TRANS.	NPRINT	0
		40	Total number of pollutants being routed (maximum = 4 , minimum = 0)[b]. When NPOLL = 0, program will route flows only and all quality operations will be bypassed.	NPOLL	0
		45	Total number of iterations to be used in routing subroutine (4 recommended).	NITER	4

---

[a] These are the only points that can be plotted by subroutine GRAPH after being routed by TRANSPORT.

[b] The three pollutants ordinarily routed are BOD, SS and coliforms. A fourth conservative pollutant may be routed if provided for on input tapes, but internal storage should not be used in this case. Not required if input is from tape or disk.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	**Format**	**Card columns**	**Description**	**Variable name**	**Default value**
13			Execution control data.		
	8F10.5	1-10	Size[a] of time-step for computation, sec.	DT	None
		11-20	Allowable error for convergence of iterative methods in routing routine (0.0001 recommended).	EPSIL	0.0001
		21-30	Total number of days (dry weather days) prior to simulation during which solids were not flushed from the sewers.	DWDAYS	0
14			Execution control data.		
	16I5	5	Control parameter specifying means to be used in transferring inlet hydrographs, *i.e.*, **NCNTRL = 0, normal transfer by tape or disk,** **NCNTRL = 1, input from cards, utilizing card groups 28, 46 and 47.**	NCNTRL	0
		10	Control parameter in estimating groundwater infiltration inflows, *i.e.*, NINFIL = 0, infiltration not estimated (INFIL not called and corresponding data omitted), NINFIL = 1, infiltration to be estimated (subroutine INFIL called).	NINFIL	0
		15	Control parameter in estimating sanitary sewage inflow, *i.e.*, NFILTH = 0, sewage inflows not estimated (FILTH not called and corresponding data omitted),	NFILTH	0

---

[a] Not required if input is from tape or disk.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
			NFILTH = 1, sewage inflows to be estimated (subroutine FILTH called).		
		20	Control parameter concerning printed output, *i.e.*,	JPRINT	0
			JPRINT = 0, flows and concentration not printed,		
			JPRINT = 1, flows and concentrations printed out in tabular form.		
		25	Control parameter concerning plotting of output,	JPLOT	0
			JPLOT = 0, plotting routine *not* called from within TRANSPORT,		
			JPLOT = 1, plotting routine *is* called from within TRANSPORT.[a]		
		30	Control parameter for hydraulic design routine, *i.e.*,	NDESN	0
			NDESN = 0, hydraulic design routine is not called,		
			NDESN = 1, hydraulic design routine is to be called.		
			REPEAT CARD GROUP 15 FOR EACH NUMBERED SEWER ELEMENT (maximum number of cards = 160). THESE CARDS MAY BE READ IN ANY ORDER.		
15			Sewer element data.		
	5I4	1-4	External element number.[b] No element may be labeled with a number greater than 1000, and it must be a positive numeral.	NOE	None

---

[a] Not operational.

[b] "External" numbers are those assigned by the user to the various sewer system components. "Internal" numbers are assigned within the program. All input to the Transport Model is in terms of external numbers.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
			However, numbering need not be consecutive or continuous.		
		******	EXTERNAL NUMBER(S) OF UPSTREAM ELEMENT(S). UP TO THREE ARE ALLOWED. A ZERO DENOTES NO UPSTREAM ELEMENT (maximum value = 1000).	******	
		5-8	First of three possible upstream elements.	NUE(1)	None
		9-12	Second of three possible upstream elements.	NUE(2)	None
		13-16	Third of three possible elements.	NUE(3)	None
		17-20	Classification of element type. Obtain value from Table 6-1.	NTYPE	16
		******	THE FOLLOWING VARIABLES ARE DEFINED BELOW FOR CONDUITS ONLY. REFER TO TABLE 6-1 FOR REQUIRED INPUT FOR NON-CONDUITS.	******	
	7F8.3	21-28	Element length for conduit, ft.	DIST	None
		29-36	First characteristic dimension of conduit, ft. See Figure 6-4 and Table 6-2 for definition.	GEOM1	None
		37-44	Invert slope of conduit, ft/100 ft.	SLOPE	0.1
		45-52	Manning's roughness of conduit.	ROUGH	0.013
		53-60	Second characteristic dimension of conduit, ft. See Figure 6-4 and Table 6-2 for definition. (Not required for some conduit shapes.)	GEOM2	None
		61-68	Number of barrels[a] for this element. The barrels are assumed to be identical in shape and flow characteristics. (Must be integer $\geq$ 1.)	BARREL	1.0

---

[a] Example: A two barrelled conduit would consist of two identical parallel conduits adjacent to each other.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
		69-76	Third characteristic dimension of conduit, ft. See Figure 6-4 and Table 6-2 for definition. (Not required for some conduit shapes.)	GEOM3	None
			CARDS 16 THROUGH 26 ARE DATA INPUT FOR INTERNAL STORAGE. (NTYPE = 19). OMIT THESE DATA CARDS IF INTERNAL IS NOT DESIRED.		
			REPEAT STORAGE MODEL DATA FOR EACH STORAGE ELEMENT (maximum = 2).		
16			Storage unit data card.		
	10I5	1-5	Storage mode parameter.[a]	ISTMOD	1
			= 1 in-line storage.		
		6-10	Storage type parameter.	ISTTYP	1
			= 1 irregular (natural) reservoir,		
			= 3 geometric (regular) uncovered reservoir.		
		11-15	Storage outlet control parameter.	ISTOUT	1
			= 1 gravity with orifice center line at zero storage tank depth,		
			= 2 gravity with fixed weir,		
			= 6 existing fixed-rate pumps,		
			= 9 gravity with both weir and orifice.		

---

[a] Must be set equal to one since other storage mode parameters are not programmed.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
17			Computation/print control card.		
	3I10	1-10	Pollutant parameter.	IPOL .	0
			= 0 no pollutants (hydraulics only),		
			= 1 perfect plug flow through basin,		
			= 2 perfect mixing in basin.		
		11-20	Print control parameter.	IPRINT	0
			= 0 no print each time-step,		
			= 1 print each time-step in storage.		
		21-30	Cost computation parameter.	ICOST	0
			= 0 no cost computations,		
			= 1 costs to be computed.		
18			Reservoir flood depth data card.		
	F10.2	1-10	Maximum (flooding) reservoir depth, ft.	DEPMAX	None
			INCLUDE EITHER CARD GROUP 19 OR 20, NOT BOTH.		
			INCLUDE CARD GROUP 19 ONLY IF ISTTYP ON CARD 16 HAS THE VALUE 1.		
19			Reservoir depth-area data card.		
	F10.2	1-10	A reservoir water depth, ft.	ADEPTH(1)	None
	F10.0	11-20	Reservoir surface area corresponding to above depth, ft^2.	AASURF(2)	None
	.	.	.	.	
	.	.	.	.	
	F10.2	61-70	A reservoir water depth, ft.	ADEPTH(4)	None

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
	F10.0	71-80	Reservoir surface area corresponding to above depth, ft^2.	AASURF(4)	None
			(NOTE: The above pair of variables is repeated 11 times, 4 pairs per card.)		
			INCLUDE CARD 20 ONLY IF ISTTYP ON CARD 16 HAS THE VALUE 3.		
20			Reservoir dimensions data card. Reservoir has shape of inverted truncated cone.		
	2F10.0	1-10	Reservoir base area, ft^2.	BASEA	None
		11-20	Reservoir base circumference, ft.	BASEC	None
	F10.5	21-30	Cotan of sideslope (horizontal/vertical).	COTSLO	None
			INCLUDE ONLY ONE OF THE OUTLET DATA CARDS 21, 22, 23 or 24.		
			INCLUDE CARD 21 ONLY IF ISTOUT ON CARD 16 HAS THE VALUE 1.		
21			Orifice outlet data card.		
	F10.3	1-10	Orifice outlet area x discharge coefficient, ft^2.	CDAOUT	None
			INCLUDE CARD 22 ONLY IF ISTOUT ON CARD 16 HAS THE VALUE 2.		
22			Weir outlet data card.		
	2F10.3	1-10	Weir height (ft) above depth = 0.	WEIRHT	None
		11-20	Weir length, ft.	WEIRL	None

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
			INCLUDE CARD 23 ONLY IF ISTOUT ON CARD 16 HAS THE VALUE 6.		
23			Pump outlet data card.		
	3F10.3	1-10	Outflow pumping rate, cfs.	QPUMP	None
		11-20	Depth (ft) at pump startup.	DSTART	None
		21-30	Depth (ft) at pump shutdown (DSTOP > 0.0).[a]	DSTOP	None
			INCLUDE CARD 24 ONLY IF ISTOUT HAS THE VALUE 9.		
24			Weir and orifice outlet data card.		
	8F10.5	1-10	Weir height above depth = 0, ft.	WEIRHT	None
		11-20	Weir length, ft.	WEIRL	None
		21-30	Orifice outlet area x discharge coefficient, ft^2.	CDAOUT	None
		31-40	Orifice centerline elevation above zero depth, ft.	ORIFHT	None
25			Initial conditions data card.		
	2F10.2	1-10	Storage (ft^3) at time zero.	STORO	None
		11-20	Outflow rate (cfs) at time zero.	QOUTO	None
			CARD 26 MUST BE INCLUDED: IT MAY BE BLANK IF ICOST ON CARD 17 HAS THE VALUE 0.		
26			Cost data card.		

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[a] DSTOP must equal or be greater than the level in storage that contains enough volume to handle the pumping rate, QPUMP, for one time-step.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
	F10.2	1-10	$/yard^3 for storage excavation.	CPCUYD	None
	2F10.0	11-20	$/acre for storage land.	CPACRE	None
		21-30	$/pump station with related structures.	CPS	None
27			List of external non-conduit element numbers at which outflows are to be transferred to subsequent blocks for a total of NOUTS (card 12) non-conduit elements.	JN	
	16I5	1-5	First element number.[a]	JN(1)	None
		6-10	Second element number.[a]	JN(2)	None
		. . . . .	Last element number.[a]	JN(NOUTS)	None
			IF NCNTRL = 0 ON CARD 14, SKIP TO CARD GROUP 29.		
28			Non-conduit element numbers into which hydrographs and pollutographs (from card input) enter the sewer system. These must be in the order in which hydrograph and pollutograph ordinates appear at each time step.		
	16I5	1-5	First element number.	NORDER(1)	None
		6-10	Second element number.	NORDER(2)	None
		. . . . .	Last element number.	NORDER(NINPUT)	None

---

[a] Element numbers transferred to subsequent blocks must be numbered less than or equal to 100.

Card group	Format	Card columns	Description	Variable name	Default value
29			List of external non-conduit element numbers at which input hydrographs and pollutographs are to be stored and printed out for a total of NNYN (card 12) non-conduit elements.	NYN	
	16I5	1-5	First input location number.	NYN(1)	None
		6-10	Second input location number.	NYN(2)	None
		. . . .		. . . .	
		.	Last input location number.	NYN(NNYN)	None
30			List of external non-conduit element numbers at which output hydrographs and pollutographs are to be stored and printed out for a total of NNPE (card 12) non-conduit elements.	NPE	
	16I5	1-5	First output location number.	NPE(1)	None
		6-10	Second output location number.	NPE(2)	None
		. . .		. . .	
		.	Last output location number.	NPE(NNPE)	None
			IF SUBROUTINE INFIL IS TO BE CALLED (NINFIL = 1), INSERT CARDS 31 THROUGH 33 OTHERWISE OMIT.		
31			Estimated infiltration.		
	10F8.1	1-8	Base dry weather infiltration, gal/min.	DINFIL	0.0
		9-16	Groundwater infiltration, gal/min.	GINFIL	0.0
		17-24	Rainwater infiltration, gal/min.	RINFIL	0.0

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
32			Control parameters.		
	I5	3-5	Day of year of estimate.[a]	NDYUD	None
	6F8.1	6-13	Peak residual moisture, gal/min.	RSMAX	0.0
		14-21	Average distance between joints, ft.	ULEN	6.0
33			Monthly degree-days.[b]	NDD	
	16I5	1-5	July degree-days.	NDD(1)	None
		6-10	August degree-days.	NDD(2)	None
		.		.	.
		.		.	.
		.		.	.
		56-60	June degree-days.	NDD(12)	None
			IF SUBROUTINE FILTH IS TO BE CALLED (INFILTH = 1), INSERT CARD GROUPS 34 THROUGH 45, OTHERWISE OMIT.		
34			Factors to correct yearly average sewage flows to daily average by accounting for daily variations throughout a typical week.		
	7F10.0	1-10	Flow correction for Sunday.	DVDWF(1)	1.0
		11-20	Flow correction for Monday.	DVDWF(2)	1.0
		.		.	
		.		.	
		.		.	
		.		.	
		61-70	Flow correction for Saturday.	DVDWF(7)	1.0

[a] Day one is July 15.

[b] See Table A-1 for values at selected locations.

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
			IF NPOLL = 0 SKIP TO CARD GROUP 37		
35			Factors to correct BOD yearly averages to daily averages.		
	7F10.0	1-10	BOD correction for Sunday.	DVBOD(1)	1.0
		. . . .			. . . .
		61-70	BOD correction for Saturday.	DVBOD(7)	1.0
36			Factors for correction of yearly SS averages to daily averages.		
	7F10.0	1-10	SS correction for Sunday.	DVSS(1)	1.0
		. . . .			. . . .
		61-70	SS correction for Saturday.	DVSS(7)	1.0
37			Factors to correct daily average sewage flow to hourly averages by accounting for hourly variations throughout a typical day (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVDWF(1)	1.0
		. . . .			. . . .
		1-10	8 a.m. to 9 a.m. factor (second card).	HVDWF(9)	1.0
		. . . .			. . . .
		1-10	4 p.m. to 5 p.m. factor (third card).	HVDWF(17)	1.0

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
			IF NPOLL = 0 SKIP TO CARD GROUP 41		
38			Factors for BOD hourly corrections (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVBOD(1)	1.0
		.			.
		.			.
		.			.
		.			.
		71-80	11 a.m. to midnight factor (third card).	HVBOD(24)	1.0
39			Factors for SS hourly corrections (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVSS(1)	1.0
		.			.
		.			.
		.			.
		.			.
		71-80	11 a.m. to midnight factor (third card).	HVSS(24)	1.0
			INCLUDE ONLY WHEN 3 POLLUTANTS ARE SPECIFIED.		
40			Factors for E. coli hourly corrections (3 cards needed).		
	8F10.0	1-10	Midnight to 1 a.m. factor (first card).	HVCOLI(1)	1.0
		.			.
		.			.
		.			.
		.			.
		71-80	11 a.m. to midnight factor (third card).	HVCOLI(24)	1.0
41			Study area data.		
	6I5	1-5	Total number of subareas within a given study area in which sewage flow and quality are to estimated.	KTNUM	None
		6-10	Indicator as to whether study area data, such as treatment plant records, are to be used to estimate sewage quality, *i.e.*,	KASE	1

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
			KASE = 1, yes, KASE = 2, no.		
		11-15	Total number of process flows within the study area for which data are included in one of the following card groups.	NPF	0
		16-20	Number indicating the day of the week during which simulation begins (Sunday = 1).	KDAY	1
		21-25	Number indicating the hour of the day during which simulation begins (1 a.m. = 1).	KHOUR	0
		26-30	Number indicating the minute of the hour during which simulation begins.	KMINS	0
	2F5.1	31-35	Consumer Price Index.	CPI	109.5
		36-40	Composite Construction Cost Index.	CCCI	103.0
	F10.3	41-50	Total population in all areas, thousands.	POPULA	None
			IF KASE = 1, INCLUDE CARD GROUPS 42, 43 and 44.		
42			Average study area data.		
	3F10.0	1-10	Total study area average sewage flow, *i.e.*, from treatment plant records, cfs.[a]	ADWF	0.0
		11-20	Total study area average BOD, mg/l.	ABOD	0.0
		21-30	Total study area average SS, mg/l.	ASUSO	0.0
	E10.2	31-40	Total coliforms, MPN/100 ml.	ACOCI	0.0

[a] If ADWF = 0.0, then total BOD, SS, and COLI will = 0.0. Predicted DWF out downstream end of system will be adjusted to this value.

Card group	Format	Card columns	Description	Variable name	Default value
43			Categorized study area data.		
	8F8.0	1-8	Total study area from which ABOD and ASUSO were taken, acres.	TOTA	None
		9-16	Total contributing industrial area, acres.	TINA	None
		17-24	Total contributing commercial area, actes.	TCA	None
		25-32	Total contributing high income (above $15,000) residential area, acres.	TRHA	None
		33-40	Total contributing average income (above $7,000 but below $15,000) residential area, acres.	TRAA	None
		41-48	Total contributing low income (below $4,000) residential area, acres.	TRLA	None
		49-56	Total area from the above three residential areas that contribute additional waste from garbage grinders, acres.	TRCGA	None
		57-64	Total park and open area within the study area, acres.	TPOA	None
			IF PROCESS FLOW DATA ARE AVAILABLE (NPF NOT EQUAL 0 AND KASE = 1), REPEAT CARD GROUP 44 FOR EACH PROCESS FLOW. OTHERWISE, SKIP TO CARD GROUP 45.		
44			Process flow characteristics.		
	I5	1-5	External manhole number into which flow is assumed to enter (maximum value = 1000, minimum value = 1).	INPUT	None
	6F10.3	6-15	Average daily process flow entering the study area system, cfs.	QPF	None
		16-25	Average daily BOD of process flow, mg/l.	BODPF	0.0
		26-35	Average daily SS of process flow, mg/l.	SUSPF	0.0

Card group	Format	Card columns	Description	Variable name	Default value
			REPEAT CARD GROUP 45 FOR EACH OF THE KTNUM SUBAREAS. THESE SUBAREAS DO NOT NECESSARILY HAVE TO CORRESPOND TO RUNOFF SUBCATCHMENTS.		
45			Subarea data.		
	2I3	1-3	Subarea number.	KNUM	None
		4-6	External number of the manhole into which flow is assumed to enter for subarea KNUM (maximum value = 1000, minimum value = 1).	INPUT	None
	3I1	7	Predominant land use within subarea, *i.e.*,	KLAND	5
			KLAND = 1, Single-family residential,		
			KLAND = 2, Multi-family residential,		
			KLAND = 3, Commercial,		
			KLAND = 4, Industrial,		
			KLAND = 5, Undeveloped or park lands.		
		8	Parameter indicating whether or not water usage within subarea KNUM is metered.	METHOD	2
			METHOD = 1, metered water use,		
			METHOD = 2, incomplete or no metering.		
		9	Parameter indicating units in which water usage estimates (WATER) are tabulated.	KUNIT	0
			KUNIT = 0, thousand gal/mo,		
			KUNIT = 1, thousand ft^3/mo.		

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
	13F5.1	10-14	Measured winter water use for subarea KNUM in the unts specified by KUNIT (not required).	WATER	None
		15-19	Cost of the last thousand gal. of water per billing period for an average consumer within subarea KNUM, cents/1,000 gal. (not required).	PRICE	None
		20-24	Measured average sewage flow from the entire subarea KNUM, cfs (not required).	SEWAGE	None
		25-29	Total area within subarea KNUM, acres (maximum = 200).	ASUB	None
		30-34	[a]Population density within subarea KNUM, population/acres.	POPDEN	None
		35-39	[a]Total number of dwelling units within subarea KNUM.	DWLINGS	10.0/ac.
		40-44	[a]Number of people living in average dwelling unit within subarea KNUM.	FAMILY	3.0
		45-49	[a]Market value of average dwelling unit within subarea KNUM, thousands of dollars.	VALUE	20.0
		50-54	[a]Percentage of dwelling units possessing garbage grinders within subarea KNUM.	PCGG	None
		55-59	Total industrial process flow originating within subarea KNUM, cfs.[b]	SAQPF	0.0
		60-64	BOD contributed from industrial process flow originating within subarea KNUM, mg/l.	SABPF	0.0
		65-69	SS contributed from industrial process flow originating within subarea KNUM, mg/l.	SASPF	0.0
		70-74	Income of average family living within subarea KNUM.	XINCOM	VALUE/2.5

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[a] Not required if KLAND greater than 2.

[b] If SAQPF = 0.0, then DWBOD and DWSS will be zero for land use 4 (i.e., for industrial flow to be considered KLAND must equal 4).

TRANSPORT BLOCK CARD DATA (Cont'd)

Card group	Format	Card columns	Description	Variable name	Default value
	12	75-76	MSUBT = 0, subtotals not made, MSUBT = 1, subtotal made. END OF FILTH DATA CARDS.	MSUBT	0
			IF NCNTRL = 0 ON CARD 14, SKIP CARDS 46 and 47.		
46			Time for start of storm.		
	F10.0	1-10	Time of day of start of storm, sec.	TZERO	0.0
			REPEAT CARD 47 FOR EACH INLET FOR FIRST TIME STEP AND THEN REPEAT CARD 47 FOR EACH INLET FOR SECOND TIME STEP, ETC. REPEAT THIS COMBINATION UNTIL ALL TIME STEPS HAVE BEEN READ.[a]		
47			Hydrograph and pollutograph input cards.		
	4F10.0	1-10	Input flow for this time step at first inlet, cfs.	RNOFF(1)	0.0
		11-20	Input BOD for this time step at first inlet, lbs/min.	PLUTO(1,1)	0.0
		21-30	Input SS for this time step at first inlet, lbs/min.	PLUTO(1,2)	0.0
		31-40	Input coliform for this time step at first inlet, MPN/min.	PLUTO(1,3)	0.0
		41-80	Not used.		
			FOR GRAPHING TRANSPORT OUTPUT, CALL GRAPH SUBROUTINE THROUGH THE EXECUTIVE BLOCK. END OF TRANSPORT BLOCK DATA CARDS.		

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[a] Note: Order of inlets must be the same as indicated in card group 28.

INPUT DATA DESCRIPTION

FOR

STORM

INPUT DATA DESCRIPTION FOR STORM

Each input card is described in detail below. Variable locations on each card are shown by field number. Most cards are divided into ten fields of eight columns each except field 1. Variables occurring in field 1 may only occupy card columns 3-8 because card columns 1 and 2 are reserved for the card identification alphanumeric character. The card identification characters will be referred to as field zero. Cards with a different format are so noted.

The different values a variable may assume and the conditions for each are described for each variable. Some variables simply indicate whether a program option is to be used or not by using the numbers -1, 0, 1, etc. Other variables contain numbers which express the magnitude of the variable. For these, a plus sign (+) is shown in the description under "value" and the numerical value of the variable is entered as input. Where the variable value is to be zero, the corresponding field may be left blank because a blank field is read as zero. A value of "AN" refers to alphanumeric characters.

a. A Cards (three cards required)

Three title cards A1, A2, and A3 for output title.

Field	Variable	Value	Description
0		A1	Card identification in columns 1 and 2.
1-10	NTITLE	AN	Job title information, preferably centered in columns 3-80. Third title card will be used as a heading on each output page.

b. B Cards (two cards required)

Job specification cards.

B1 Card (required)

Field	Variable	Value	Description
0		B1	Card identification.
1	NWSHD	+	Number of watersheds to be analyzed. Calls for NWSHD sequences of E through T cards as required. Default = 1.
2	ISNO	0	No snowmelt computations are desired. Omit D cards.
		1	Snowmelt computations are to be made using D cards.
3	NONURB	0	Nonurban watershed computations will not be made. Omit H, J, and K cards.
		1	Nonurban watershed computations will be performed using H, J, and K cards as required.
4	ISED	0	No land surface erosion computations will be made. Omit * through R cards.
		1	Land surface erosion computations will be made using * through R cards.
5	IQUAL	0	No water quality computations will be made. F2 cards are still required even though blank.
		1	Water quality computations will be made.
6	IEVNT	0	No detailed analysis (pollutograph) of selected events is desired. IPOLMX (T2-3) will be zero.
		1	Detailed event analysis will be required, IPOLMX (T2-3) may be greater than zero.

B2 Card (required)

Climatic data.

Field	Variable	Value	Description
0		B2	Card identification
1	NSUMR	+	Length, in days, of average summer (period of no rain), default = 42.
2	LEXT	+	Number of initial hours of overflow for which separate quantity and quality reporting is desired (default = 3).
3	LINE	+	Number of years of rainfall represented on rainfall record (default = computed value).
4	LDATE	+	Date (YR, MO, DY) of the end of rainfall for the last major precipitation preceding the first rainfall record. Six columns right justified. (default = 6 days).
		-	Number of days since the end of rainfall from last precipitation preceding the first rainfall record. (Default = 6)
5	LHR	+	Hour of last major precipitation preceding the rainfall record. (Default = midnight)

c. C Cards

Precipitation data.

C1 Card (required)

Field	Variable	Value	Description
0		C1	Card identification.
1-4	NAME	AN	Title of precipitation record, columns 3-32 inclusive.
5	IN	5	Precipitation data is to be supplied on C2 cards.
		+	Unit number for precipitation data tape/disk. No C2 cards are read. Format is same as on C2 card.
		-	Previously generated unformatted binary tape/disk rainfall/snowmelt records will be used on FORTRAN logical unit 12. Omit C2 and D cards. This is a time saving option in that the basic precipitation and temperature data need only be processed once. Upon generation of a satisfactory rainfall/snowmelt file, the tape/disk on logical unit 12 should be saved for future use under this option.
6	IFILE	+	Number of tape files to be skipped in order to reach precipitation records. Used only if data is read from tape.
7	ISTART	+	Date (six digit integer for year, month and day) of first precipitation record to be analyzed. Default equals first day of the precipitation record. Can be used to start analysis at any point in a precipitation record.
8	IEND	+	Date of the last precipitation record to be analyzed. Default equals last day in the precipitation record. Not to be used if input precipitation data is on cards.
9	IR	0	Input precipitation (snowmelt) record will not be output on printer.
		1	Print input precipitation record.

C2 Card (Required only if IN(C1-5) is 5). Format (2X, I6, 24I3).

Field	Variable	Value	Description
0		C2	Card identification.
1	KDATE	+	Date of rainfall data on this card. Year, month and day specified in six columns: 3-4, year number; 4-6, month number; 7-8, day number.
2-25	KRAIN	+	Hourly rainfall in hundredths of an inch per hour specified in 24 three-column fields.

Repeat one C2-card for each day of rainfall. A blank C2-card must follow the last day of rainfall.

d. D Cards (two cards required only if ISNO (B1-2) is greater than zero). Snowmelt parameters.

D1 Card (Required only if ISNO (B1-2) is greater than zero).

Field	Variable	Value	Description
0		D1	Card identification.
1	ITAPE	+	Input unit for temperature data.
2	IFILE	+	Number of files to be skipped to reach file in which starting record occurs.
3	IFREZ	+	Temperature (integer) below which snow falls and above which snow melts.
4	IPACK	+	Starting snowpack water equivalent over basin in hundredths of an inch.
5	ITMP	0	Average temperatures are on D3 card.
		1	Max/Min temperatures are on D3 card.
6	COEF	+	Degree-day melt rate coefficient. Default = .07.

D2 Card (Required only if ISNO (B1-2) is greater than zero).

Daily temperature data in Weather Bureau format (5X, I6, 2I3, 55X, I3). Only Max/Min or average temperatures are necessary as indicated by ITMP (D1-5).

Field	Variable	Value	Description
0		D3	Card identification or station identification in Cols. 1 through 5.
1	JDATE	+	Date, integer, six digits for year, month and day in Cols. 6 through 11.
2	IMAX	+	Maximum daily temperature, °F, Cols. 12-14.
3	IMIN	+	Minimum daily temperature, °F, Cols. 15-17.
4	ITEMP	+	Average daily temperature, °F, Cols. 72-74.

D2 Cards are repeated for each month for the period of analysis. All days of the month are to be included even for the last month.

e. E Cards (required)

E through T cards (as required) are repeated for each watershed. The previous rainfall (snowmelt) pattern, KRAIN as modified by snow routine, will be used for each watershed.

Field	Variable	Value	Description
0		E1	Card identification.
1-2	NAMEWS	AN	Title of watershed.
3	MXLG	+	Number of land use groups modeled (Max = 5). MXLG pairs of F1, F2 cards will be read for land uses as defined on F1 card.
4	EXPTE	+	Exponent for dust and dirt washoff, equation (7) in text: $M_p = P_c (1 - e^{-EXPTE*\Delta t})/\Delta t$ *Default = 4.6
5	REFF	+	Street sweeping efficiency (ratio of material picked up to the total material on the street) as a decimal fraction (default = 0.70).

E2 Card (Required)

Field	Variable	Value	Description
0		E2	Card identification.
1	AREA	+	Total urban area, in acres, of the watershed.
2	CPERV	+	Runoff coefficient for pervious areas (default = .15).
3	CIMP	+	Runoff coefficient for impervious areas (default = .90).
4	RFU	+	Factor by which KRAIN, rainfall array, is multiplied to obtain average rainfall over urban area.
5	IQU	0	No hydrographs are to be input on G cards.
		1	Hydrographs will be read on G cards and be used to override computed runoff during periods indicated.
6	DVU	+	Minimum flow (cfs) above which flow from the urban area is diverted (default=no diversion).
7	DVUMX	+	Maximum flow (cfs) above which all additional flow is diverted.
8	WU	+	Proportion of available flow between DVUMX and DVU that is diverted.

E3 Cards (two cards required)

Initial loss rate and recovery data.

Field	Variable	Value	Description
0		E3	Card identification.
1	DEPRS	+	Depression storage, average over total watershed, in inches.
2	RECVRT	+	Potential evaporation rate, inches/day (for recovery of depression storage) for January.
3	RECVRT	+	Evaporation rate for February. Continue similarly for March through December.

f. F Cards (two cards required for each land use)

F1 Card (required)

Land use data. F1, F2 card pairs are repeated for each of MXLG (E1-3).

Field	Variable	Value	Description
0		F1	Card identification.
1	LNDUSE	SINGLE	Single family dwellings.
		MULTPL	Multiple family dwellings.
		COMMCL	Commercial development.
		INDSTL	Industrial development.
		OPEN--	Open or park area. Nonurban land use is described separately on H cards.
2	PRCNT	+	Percent of urban watershed area (card E2-1) in this land group.
3	FIMP	+	Percent imperviousness of this land group.
4	STLEN	+	Length of street gutters in feet per acre.
5	NCLEAN	+	Number of days between street sweeping in each land use group (see Note 1 for default value).

F2 Card (required)

Pollutant accumulation and contents. See Note 1.

Field	Variable	Value	Description
0		F2	Card identification.
1	DD	+	Daily rate of accumulation of dust and dirt in pounds per 100 feet of gutter. See Note 1 for default value.
2	FRACTN(L, 1)	+	Pounds of suspended solids per 100 pounds of dust and dirt (see note 1 for default value).
3-6	FRACTN(L, 3-6)	+	Pounds of settleable solids, BOD, Nitrogen and orthophosphate respectively per 100 pounds of dust and dirt. See Note 1 for default values.

g. G Cards (Required only if IQU (E2-5) is greater than zero).

Direct input urban hydrograph data.

G1 Card

Field	Variable	Value	Description
0		G1	Card identification.
1	A	+	Transformation factor "A" for the input urban hydrograph, QU, (G2-3) according to the following equation: QU = A + B*QU
2	B	+	Urban hydrograph transformation factor B.

G2 Card

Field	Variable	Value	Description
0		G2	Card identification.
1	IDQU	+	Station identification, integer.
2	IDATE	+	Date, integer, of flow to be input. Must correspond to a date in the rainfall/snowmelt array.
3	QU(1)	+	Average flow during first hour of day IDATE.
4	QU(2)	+	Average flow during second hour of day IDATE.
5-10	QU	+	Average flow during hours 3-8. Following two G2 cards have same format for hours 9-16 and 17-24 respectively. G2 cards are repeated for all days for which flow is to be input. A blank card ends the G2 card sequence. Maximum of 100 days in ascending sequence.

h. H Cards (required only if NONURB, B1-3, is greater than zero). Nonurban watershed data.

H1 Card

Field	Variable	Value	Description
0		H1	Card identification.
1	AREAN	+	Area of nonurban part of watershed in acres.
2	CN	+	Runoff coefficient for nonurban area; water excess will be multiplied by this factor in order to determine runoff.
3	RFN	+	Factor by which KRAIN, rainfall array, is multiplied to obtain average rainfall/ snowmelt over nonurban area.
4	IQN	0	No hydrographs are to be input on K cards.
		1	Hydrograph(s) are to be input on K cards.
5	DVN	+	Minimum flow (cfs) above which flow from the nonurban area is to be diverted. (Default = no diversion).
6	DVNMX	+	Maximum flow (cfs) from nonurban area, above which no additional flow can be diverted.
7	WN	+	Fraction of available flow that is actually diverted.
8	EXPTN	+	Exponent for pollutant washoff from nonurban area. Similar to EXPTE (E1-5) for the urban area. Default = 4.6.

H2 Cards

Field	Variable	Value	Description
0		H2	Card identification.
1	DEPRN	+	Depression storage, in inches, over nonurban area.
2	RECVN(1)	+	Potential evaporation rate, inches/ day (for recovery of nonurban depression storage) for January.
3	RECVN(2)	+	Potential evaporation rate for February. Continue similarly for March through December on this and next H2 card.

i. J Card (required only if H cards are used)

Pollutant accumulation on nonurban area of the watershed. See Note 2 for suggested values. There are no defaults for these variables.

Field	Variable	Value	Description
0		J1	Card identification.
1	POL(1)	+	Pollutant accumulation rate for suspended solids in lbs/acre/day.
2-5	POL(2)	+	Pollutant accumulation rate for settleable solids in lbs/acre/day. Similarly for BOD, total nitrogen and orthophosphate, PO_4.

j. K Cards (Required only if IQN, H1-4, is greater than zero)

Direct input nonurban hydrograph data.

K1 Cards

Field	Variable	Value	Description
0		K1	Card identification.
1	A	+	Transformation factor "A" for the input nonurban hydrograph, QN, (K2-3), according to the following equation: QN = A + B*QN.
2	B	+	Nonurban transformation factor B.

K2 Cards

Field	Variable	Value	Description
0		K2	Card identification.
1	IDQN	+	Station identification, integer.
2	NDATE	+	Date, integer, of flow to be input. Must correspond to a date on rainfall/snowmelt record.
3	QN(1)	+	Average flow during first hour of day NDATE.
4-10	QN(2)	+	Average flow during second hour of day NDATE, and for following hours 3-8. Following two K2 cards have same format for hours 9-16 and 17-24 respectively. K2 cards are repeated for all days for which flow is to be input. A blank card ends the K2 card sequence.

LAND SURFACE EROSION

Cards * through R form the input set for calculating land erosion. The set is divided between cards describing the soil characteristics under natural conditions - this would be * through P4 and the construction and land use requirements to develop the site described on cards Q and R.

k. * Card

Comment cards. To describe and identify the land surface erosion data. Use as many as needed.

Field	Variable	Value	Description
0		*	Card identification.
1-10			Any α-numeric data that is required to identify and describe the soil erosion analysis. If more than one card is required, show again the * in column 1 and title information across that card, continuing until all the title information is entered.

l. P Card

Soil series identification.

Field	Variable	Value	Description
0	ICG	P	Card identification.
1-10			α-numeric description of the soil series identification by slope and soil type.

P1 Card

Job parameters.

Field	Variable	Value	Description
0	ICG	P1	Card identification.
3	MDS	+	Maximum number of depths in the soil column. P4-card soil properties are identified at MDS depths beneath the ground surface (default = 3).
4	MPD	+	Maximum number of soil parameters for each depth entry. P4-card shows one parameter "XK" for each depth entry.
5	MCSC	+	Maximum number of characters in the soil classification code (default = 3).
6	MCSG	+	Maximum number of characters in the slope group (default = 1).
7	WF	+	The range of WF is 0 to 1. A 0 value weights the natural ground slope to the minimum value of the soil group. A value of 1 weights the natural ground slope to the maximum value for this soil group (default =.5).
8	RMI	+	Ratio of maximum hourly intensity to the maximum 30 minute intensity. If the maximum 30 minute intensity is available from rainfall tapes, the RMI value is not used (default = 0.8).
9	SMEC	+	Snowmelt erosion coefficient for reduction of erosion related energy (default = .33 of the rainfall value).

P2 Card

Ground Slope Data

Field	Variable	Value	Description
0	ICG	P2	Card identification.
3	NSG	+	Number of the slope group which the following slope values describe.
4	SLOPE	+	SCS designated slopes that describe ground surface slope. All of the soil series identification codes can be divided into two slope groups. Therefore, two P2 cards are required. The distinguishing factor is the rate of change of slope with designations "a" through "e". Express in percent.

P4 Card

Soil properties

Field	Variable	Value	Description
0	ICG	P4	Card identification.
2	KSP	+	Enter the first two digits in the α-numeric code assigned by SCS to identify soil series. Group all soils in the same slope group together. Use as many P4 cards as are required to describe each soil type.
3	NSG	+	The soil type on this card belongs to slope group NSG, reference card P2.
4	DEPTH	+	The depth below the ground surface in inches for which soil properties have been identified.
5	XK	+	Soil-erodibility factor (K) in the universal soil-loss equation. Enter one value for each depth and as many depths as MDS on card P1.

P5 Card (Optional)

Changes default values of erosion potential factors.

Field	Variable	Value	Description
0	ICG	P5	Card identification.
1-2			Alpha-numeric description.
3-9			Use same variables as fields 3-9 of R-Card.

m. Q Card

Sediment trap data

Field	Variable	Value	Description
0	ICG	Q	Card identification.
3	TEFF	+	Trap efficiency desired for the sediment detention reservoirs. If none is desired this card may be omitted.

n. R Card

Erosion potential model by land use. The R card data describes potential development by land use as it will impact on sediment erosion potential. Any number of R Cards may be used. The entire basin may be modelled or a small portion may be selected as a sample and the model constructed for the sample. The sample will be expanded automatically by the program to represent the entire basin.

Field	Variable	Value	Description
0	ICG	R	Card identification.
1-2	ISI	+,A	Two entries are made into the variable ISI array. The first is land use using the land use code as follows:
		SINGLE	Single family units.
		MULTPL	Multiple family units.
		COMMCL	Commercial use.
		INDSTL	Industrial.
		OPEN	Open area, such as parks or non-developed urban area.
		NONURB	Nonurban land which contributes water and sediment runoff to the urban area.
			The second entry in ISI is the soil series identification for the land used. It may come from the table of values entered on Card P4, in which case the slope and soil-erodibility properties can be determined from that table. (Otherwise, these values may be entered on the R card, and depth of cut or fill calculations cannot be made.)

R Card (cont.)

Field	Variable	Value	Description
3	PALU	+	Percent of area in this land use category that has the soil and slope properties to be defined on this R card. PALU values are summed for all R cards specifying the same land use and if this summation is less than 100 percent R cards only sample land use in the basin and that sample will be expanded to include the entire basin by the program.
4	XLTH	+	The length of lot in the direction of the ground slope expressed in feet. This must be an average value for the percent of land use shown on this R. card.
5	XS	+	The lot slope is entered in percent and for those lots sloping away from the street it should be a plus value.
		-	Those lots sloping towards the street can be entered as having a negative slope in percent and will be considered as contributing sediment to the streets or impervious surface system. Use the same technique for impervious areas other than streets.
6	GCOV	+	This is a cropping-management factor in % (see the universal soil loss equation.) Its values are identified in that reference. As used here it is a ground cover factor to ratio erosion from land having vegetation or some other cover to the erosion plot values determined by the equation.
7	ECP	+	The erosion control practice factor (P) in % is included because it is part of the universal soils loss equation. The standard default value in this program is one. A table of factors on contouring or terracing is included.
8	XK	+	This is the soil erodibility factor (K) for the universal soil loss equation. Its value needs to be determined by soils experts.
9	SDR	+	The sediment delivery ratio is a factor that accounts for deposition in the basin between the erosion plot being analyzed and the basin outflow point. A standard default value of 0 for those lots sloping away from street, and one for those lots sloping towards the street or unimpervious area.

o. END Card

After the last R Card, include a card with the word "END" in the first three columns to identify that all sediment yield data has been entered.

p. T Cards

Treatment rate and storage capacity alternative.

T1 Card (required)

Field	Variable	Value	Description
0		T1	Card identification.
1	MAX	+	Number, integer, of treatment rates to be investigated. MAX sets of T2 through T5 cards, as required, will be input, (maximum = 20).

T2 Card (required)

Treatment rate, storage capacity and pollutograph data.

Field	Variable	Value	Description
0		T2	Card identification.
1	TRATER (M)	+	Treatment rate in inches per hour for NX (T2-2) storage capacities.
2	NX	+	Number of storage capacities (on T3 cards) to be used in conjunction with above treatment rate (default = 1, maximum = 20).
3	IPOLMX	+	Number of selected events to be printed as listed by event number on T4 card. If this is used, IEVNT, (B1-6), must be greater than zero.
		0	No selected events.
4	IPLOT	0	Do not plot storage utilization curve.
		1	Plot storage utilization curve.
5	IPRINT	0	Suppress printout of individual events. Only summary information will be printed for quantity and quality analyses.
		1	Print all events for quantity analysis and summary listing for both.
		2	Print all events for quality analysis and summary listing for both.
		3	Print all events and summaries for both quantity and quality.

T2 Card (cont.)

Field	Variable	Value	Description
6	IPRTS	0	Suppress event listing for sediment report.
		1	Print land surface erosion information for each event suppressing breakdown by individual urban land use.
		2	Print complete land surface erosion information for each event.
7	IERDMX	+	Number, integer, of events for which complete land surface erosion information is required. Not used if IPRTS is 1 or 2. Maximum of 20. Event numbers are specified on T5 cards.

T3 Card (required)

Storage capacities.

Field	Variable	Value	Description
0		T3	Card identification.
1	CAPR(M,1)	+	Storage capacity in inches for first of NX (T2-2) storages to be analyzed.
2	CAPR(M,2)	+	Storage capacity in inches for second storage to be analyzed. This and the remaining storages are to be entered in successive fields.

T4 Card (required if IPOLMX (T2-3)>0)

Even numbers for pollutographs.

Field	Variable	Value	Description
0		T4	Card identification.
1	IPOLUT(1)	+	Event number of first of IPOLMX (T2-3) selected events to be printed.
2	IPOLUT(2)	+	Event number of second selected event to be printed. This and remaining events are to be entered in successive fields.

T5 Card (required if IERDMX (T2-7)>0)

Even numbers for printing of land surface erosion data.

Field	Variable	Value	Description
0		T5	Card identification.
1	IERD(1)	+	Event number of first of IERDMX (T2-7) selected events for which land surface erosion data is to be printed.
2	IERD(2)	+	Event number for second selected event. Similarly for remaining events.

NOTE 1

Defaults* for quality data are as follows:

Variable Name Land Use	NCLEAN (F1-5) Sweeping Interval, Days	DD(F2-1)* DD rate lb/d/100 ft	FRACTN (F2-3, 7)* lb Pollutant/100 lb DD				
			SUS	SET	BOD	NIT	PO_4
Single Family Res.	90.0	.7	11.1	1.1	.500	.048	.005
Multiple Family Res.	90.0	2.3	8.0	.8	.360	.061	.005
Commercial	90.0	3.3	17.0	1.7	.770	.041	.007
Industrial	90.0	4.6	6.7	.7	.300	.043	.003
Open or Park	90.0	1.5	11.1	1.7	.500	.048	.005

* Data obtained from American Public Works Association, "Water Pollution Aspects of Urban Runoff," Water Pollution Control Research Series, Federal Water Pollution Control Administration, Report No. WP-20-15, January 1969.

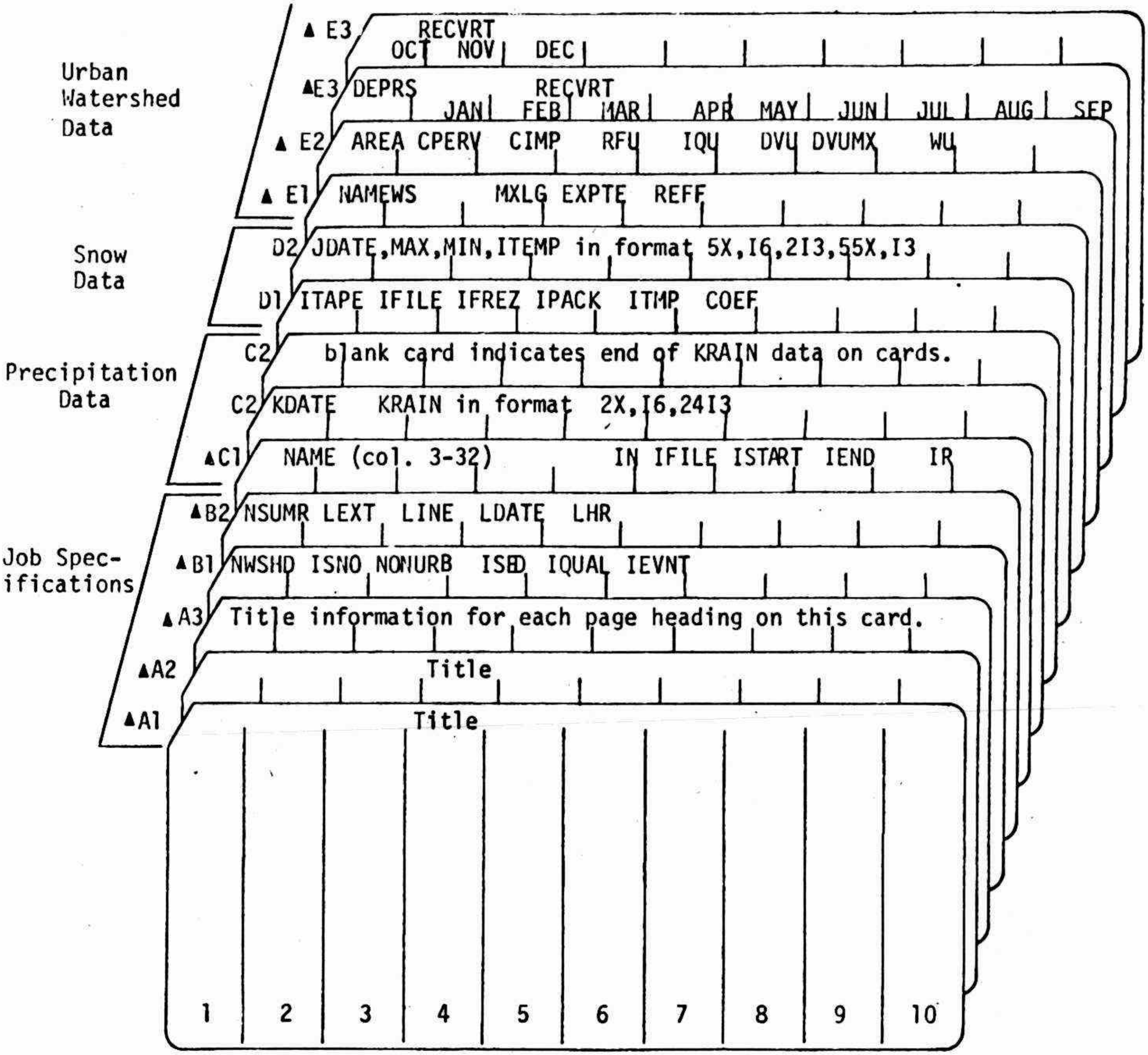
NOTE 2

Suggested* Values for Nonurban Pollutant Loading Rates:

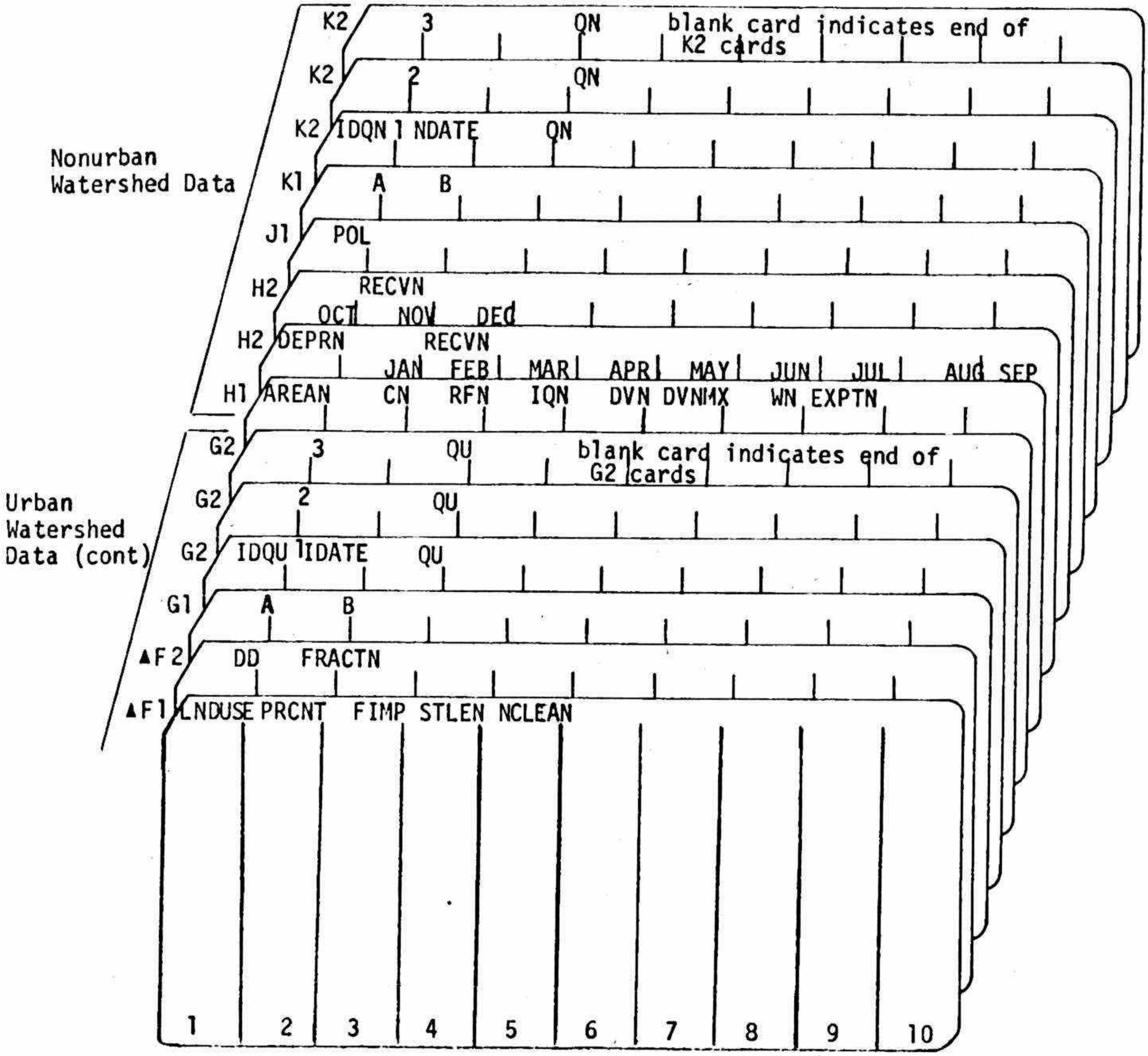
	Input Variable POL (J-1, 5)* lb Pollutant/Day/Acre				
Land Use	Suspended	Settleable	BOD	N	PO_4
Open Space and Rural			.03	.007	.003
Agricultural (pastures)			3.1	.5	.35
Agricultural (farming)			.02	.23	.07
Forests (Douglas Fir)			.01	.002	.00002

*Values obtained from Cornell, Howland, Hayes and Merryfield, Seattle, WA. General data are not currently available for suspended and settleable solids; consult local water quality experts concerning these values.

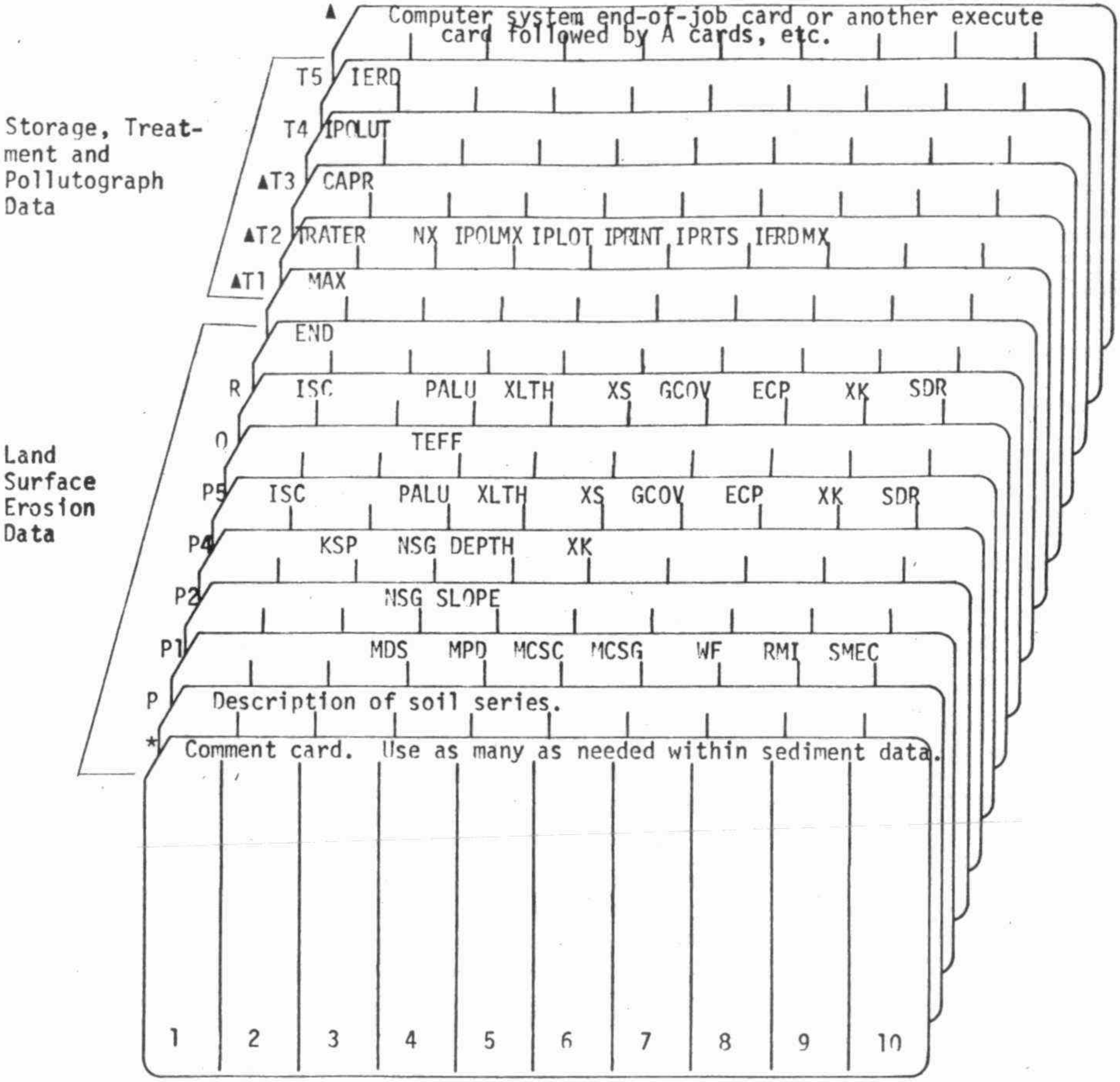
SUMMARY OF INPUT CARDS


Urban Watershed Data
Snow Data
Precipitation Data
Job Specifications
▲ E3 RECVRT OCT NOV DEC
▲E3 DEPRS RECVRT JAN FEB MAR APR MAY JUN JUL AUG SEP
▲ E2 AREA CPERV CIMP RFU IQU DVU DVUMX WU
▲ E1 NAMEWS MXLG EXPTE REFF
D2 JDATE,MAX,MIN,ITEMP in format 5X,I6,2I3,55X,I3
D1 ITAPE IFILE IFREZ IPACK ITMP COEF
C2 blank card indicates end of KRAIN data on cards.
C2 KDATE KRAIN in format 2X,I6,24I3
▲C1 NAME (col. 3-32) IN IFILE ISTART IEND IR
▲B2 NSUMR LEXT LINE LDATE LHR
▲ B1 NWSHD ISNO NONURB ISED IQUAL IEVNT
▲A3 Title information for each page heading on this card.
▲A2 Title
▲A1 Title
1
2
3
4
5
6
7
8
9
10

▲ Required cards. Other cards are required depending upon input options.


Nonurban Watershed Data
K2 3 QN blank card indicates end of K2 cards
K2 2 QN
K2 IDQN 1 NDATE QN
K1 A B
J1 POL
H2 RECVN OCT NOV DEC
H2 DEPRN RECVN JAN FEB MAR APR MAY JUN JUL AUG SEP
H1 AREAN CN RFN IQN DVN DVNMX WN EXPTN
Urban Watershed Data (cont)
G2 3 QU blank card indicates end of G2 cards
G2 2 QU
G2 IDQU 1 IDATE QU
G1 A B
▲F2 DD FRACTN
▲F1 LNDUSE PRCNT FIMP STLEN NCLEAN
1
2
3
4
5
6
7
8
9
10

▲ Required cards. Other cards are required depending upon input options.


▲ Computer system end-of-job card or another execute card followed by A cards, etc.
Storage, Treatment and Pollutograph Data
T5 IERD
T4 IPOLUT
▲T3 CAPR
▲T2 TRATER NX IPOLMX IPLOT IPRINT IPRTS IERDMX
▲T1 MAX
END
Land Surface Erosion Data
R ISC PALU XLTH XS GCOV ECP XK SDR
O TEFF
P5 ISC PALU XLTH XS GCOV ECP XK SDR
P4 KSP NSG DEPTH XK
P2 NSG SLOPE
P1 MDS MPD MCSC MCSG WF RMI SMEC
P Description of soil series.
* Comment card. Use as many as needed within sediment data.
1
2
3
4
5
6
7
8
9
10

▲ Required cards. Other cards are required depending upon input options.

FINAL REMARKS

INTERFACING URBAN STORM WATER MODELS

Paul E. Wisner
James F. MacLaren Limited

1. MODEL LIMITATIONS

- Few models, if any, are completely universal and, therefore, some caution should be exercised when an existing model is applied in a new and untested role.
- The limitations of some well-accepted models noted in Table 1 indicate some of the situations in which these models do not perform well.

TABLE I. SOME GENERAL MODEL LIMITATIONS

Model	Comment
STORM	- peak flows not accurate due to 1 hour time step and no flow routing - simplistic storage and treatment routines
SWMM	- antecedent conditions have usually to be assumed - poor simulation of hydrographs in surcharged systems - not well validated for predominantly rural areas - quality model hard to calibrate, somewhat oversophisticated for most applications - receiving water model does not account for pollutant transport by diffusion
WREM	- very short time steps required to avoid unstability - extensive data requirements

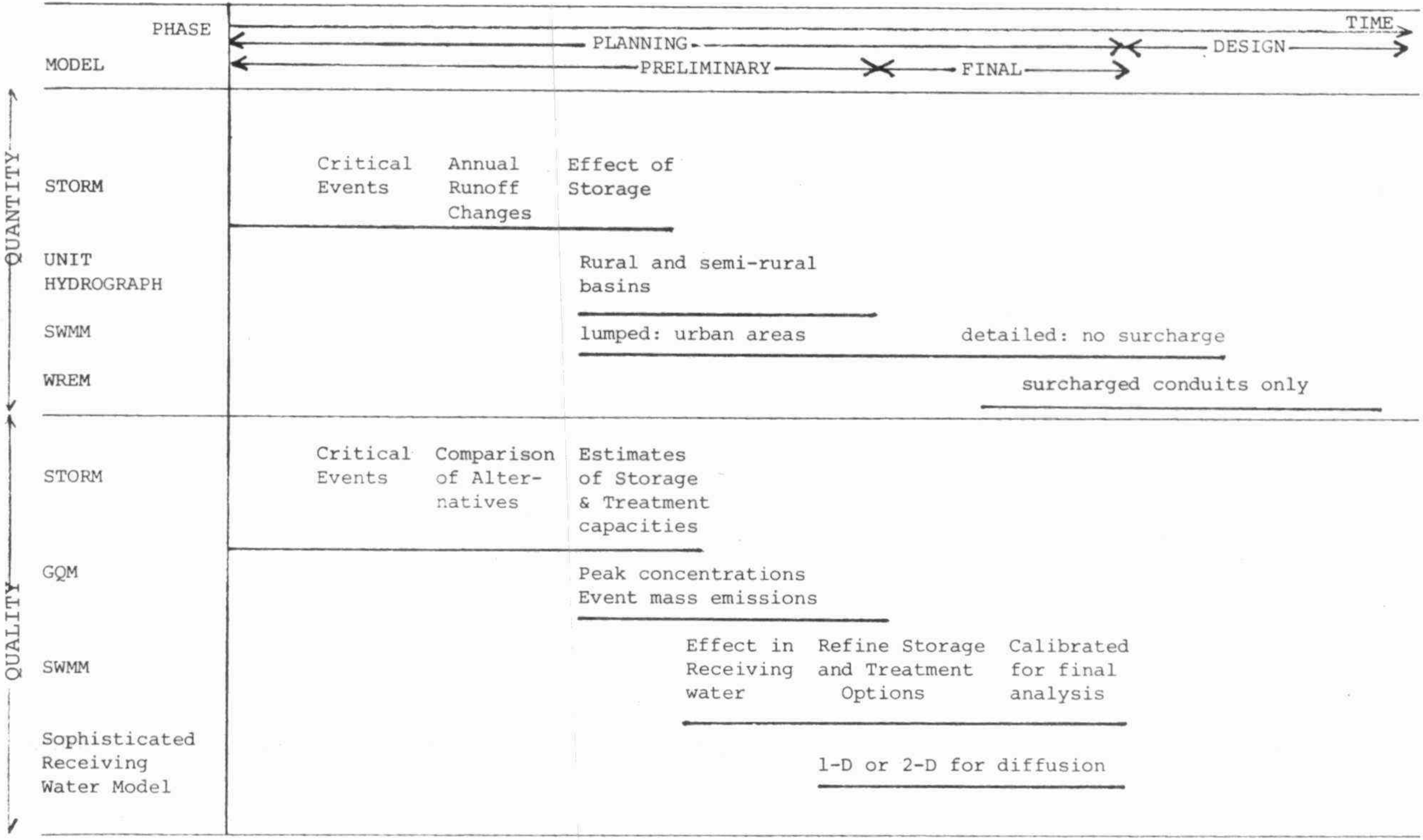
2. HIERARCHY OF MODELS

- The designation of STORM as a "planning model" or SWMM as a "design model" may cause a user to be model oriented rather than problem oriented.
- The early planning stages of some urban drainage projects are typified by limited amounts of relevant data and several alternative patterns for development or solution of existing problems. The use of a simple model, such as STORM, at this stage represents an economic approach to screening alternative policies at a level of sophistication compatible with available data and acceptance by nontechnical planners and decision-makers.
- In the final planning stages of the project, more detailed information and monitoring results become available and the number of alternatives is reduced. At this stage a detailed simulation involving fine discretization and calibration for accurate water quality prediction is warranted. At this juncture, the effects of untreated and treated discharges to the receiving water would be assessed.
- The WRE model is sometimes employed in final planning for an analysis of the benefits of surcharged design. According to our experience in studies conducted in Winnipeg, Port Credit and Edmonton, the intentional use of surcharge in the design of relief sewers or in the analysis of interceptor capacity can lead to considerable reduction in peak storm water flows. Consequently, it appears reasonable to employ only a model with sophisticated routing, such as the WREM, capable of simulating surcharged flow in the design of relief sewers or in the final planning phase of new projects where in-line storage by surcharge is feasible.
- During the course of a project from screening to design, model sophistication, data requirements and computer costs will all increase. The results of each model should lead logically to the next, more sophisticated application and good communications with the decision-makers should ensure a shared objective. The involvement of nontechnical planners and decision-makers in regular consultation is essential in this regard.

3. MODEL INTERFACE

- The experience in a number of research and practical urban drainage and pollution control studies confirms that modelling is a dynamic process. No single model or unique pattern of application can be recommended.
- Best results are likely to be achieved with a series of interfaced models applied within proven limitations. This approach may logically result in the ultimate acceptance of highly sophisticated continuous simulation models in the final planning phase of most major watershed studies.

TABLE 2. THE ROLE OF MODELS IN DIFFERENT PHASES OF DRAINAGE STUDIES


PHASE
MODEL
TIME
PLANNING
DESIGN
PRELIMINARY
FINAL
QUANTITY
QUALITY

	MODEL	
QUANTITY	STORM	Critical Events Annual Runoff Changes Effect of Storage
	UNIT HYDROGRAPH	Rural and semi-rural basins
	SWMM	lumped: urban areas detailed: no surcharge
	WREM	surcharged conduits only
QUALITY	STORM	Critical Events Comparison of Alternatives Estimates of Storage & Treatment capacities
	GQM	Peak concentrations Event mass emissions
	SWMM	Effect in Receiving water Refine Storage and Treatment Options Calibrated for final analysis
	Sophisticated Receiving Water Model	1-D or 2-D for diffusion

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Notes : storm water
management model workshop.

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